



**CITY OF AUSTIN**  
**WATERSHED PROTECTION DEPARTMENT**

**PROJECT MANUAL**  
**Contract Documents and Technical Specifications**

**VOLUME 2 of 3**

**WALLER CREEK CATENARY PILOT**

**C.I.P. PROJECT NUMBER: 10878.003**  
**SOLICITATION NUMBER: CLMC870**

Prepared by



AECOM Technical Services, Inc.  
9400 Amberglenn Blvd  
Austin, Texas, 78729  
TBPE REG. No. F-3580

**CITY OF AUSTIN**  
**Watershed Protection Department**  
**411 Chicon Street**  
**Austin, TX 78702**

**June 2021**

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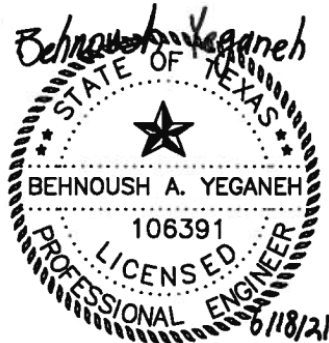


**CITY OF AUSTIN**  
**Watershed Protection Department**  
**PROJECT MANUAL**  
**FOR**  
**WALLER CREEK CATENARY PILOT**

Casey Wauters, P.E.  
AECOM  
Civil



Behnoush Yeganeh, P.E.  
AECOM  
Mechanical



Shelby G. Eckols, P.E.  
AECOM  
Structural



Kegham Harutunian, P.E.  
Harutunian Engineering, Inc.  
Electrical/I&C



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*Certifications*

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**VOLUME 1**

05/17/2021 Table of Contents

**BIDDING REQUIREMENTS, CONTRACT FORMS, & CONDITIONS OF THE CONTRACT**

00020	05/10/21	Invitation for Bids
00100	05/10/21	Instructions to Bidders
00300L	05/10/21	Bid Form-Lump Sum
	04/03/20	Total Bid Form
00400	04/30/19	Statement of Bidder's Experience
00405	03/30/18	Certificate of Non-Suspension or Debarment
00410	09/17/18	Statement of Bidder's Safety Experience
00440	10/22/19	Prohibited Activities
00500	02/04/20	Agreement (SAMPLE)
00610	02/04/20	Performance Bond
00620	02/04/20	Payment Bond
00630	10/22/19	Non-Discrimination and Non-Retaliation Certificate
00631	03/30/18	Title VI Assurances Appendix A
00632	03/30/18	Title VI Assurances Appendix E
00650	06/08/18	Certificate of Insurance
00670	01/11/19	Sales Tax Exemption Certificate
00680	03/30/18	Non-Use of Asbestos Affidavit (Prior to Construction)
00681	03/30/18	Non-Use of Asbestos Affidavit (After Construction)
00700	12/04/20	General Conditions
00810	05/10/21	Supplemental General Conditions
00819	01/22/21	Security Requirements
00830	02/04/20	Wage Rates and Payroll Reporting
00830BC	05/17/21	Wage Rates Building Construction Trades
00840	05/10/21	Construction Training Program Requirements
00900	05/10/21	Addendum (SAMPLE)

**Table of Contents**

---

**SPECIFICATIONS**

**Division 1 - General Requirements**

01010	08/28/20	Summary of Work
01025	09/17/18	Measurement and Payment Lump Sum Contracts
01040	01/22/21	Project Coordination
01046	04/23/21	Sequence of Construction
01050	10/19/15	Grades Lines & Levels
01095	07/21/03	Reference Standards and Definitions
01200	08/09/12	Project Meetings
01300	01/11/19	Submittals
01310	01/22/21	Schedules and Reports
01352	06/29/18	Sustainable Construction Requirements
01353	04/29/20	Construction Equipment Emissions Reduction Plan
01380	08/09/12	Construction Photography & Videos
01400	01/22/21	Quality Control Services
01445	01/22/21	Manufacturer's Field Services
01500	08/28/20	Temporary Facilities
01505	08/12/19	Construction and Demolition Waste Management
01550	08/09/12	Public Safety and Convenience
01600	01/22/21	Materials and Equipment
01730	01/22/21	Operation and Maintenance Data
01900	03/12/12	Prohibition of Asbestos Containing Materials
01900a	06/05/06	Statement of Non-Inclusion of Asbestos Containing Material (E/A Prior to Design)
01900b	06/05/06	Statement of Non-Inclusion of Asbestos Containing Material (E/A After Design)

**City Standard Technical Specifications**

**Series 100 – Earthwork**

104S	09/26/12	Removing Portland Cement Concrete
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**Series 200 – Subgrade and Base Construction**

NOT USED

**Series 300 – Street Surface Courses**

NOT USED

**Series 400 – Concrete Structures and Miscellaneous Concrete**

403S	09/26/12	Concrete for Structures
405S	11/13/07	Concrete Admixtures
406S	09/26/12	Reinforcing Steel
408S	11/13/07	Concrete Joint Materials
409S	11/13/07	Membrane Curing
410S	09/26/12	Concrete Structures
411S	11/13/07	Surface Finishes for Concrete
413S	11/13/07	Cleaning and/or Sealing Joints and Cracks (PCC)

**Series 500 – Pipe and Appurtenances**

NOT USED

**Series 600 – Environmental Enhancement**

NOT USED

---

**Table of Contents**


---

**Series 700 – Incidental Construction**

700S      09/26/12      Mobilization

**Series 800 – Urban Transportation**

802S      09/26/12      Project Signs

**Special Provisions to City Standard Technical Specifications**

SP403S      10/24/18      Special Provision to Concrete for Structures

SP406S      09/06/16      Special Provision to Reinforcing Steel

SP410S      10/25/18      Special Provision to Concrete Structures

**VOLUME 2 OF 3****Special Specifications****Division 2 – Site Construction**

NOT USED

**Division 3 – Concrete**

NOT USED

**Division 4 – Masonry**

NOT USED

**Division 5 – Metals**

05010      01/22/21      Metals for Structures

05015      01/22/21      Stainless Steel Fabrications

05120      01/22/21      Structural Steel

05500      01/22/21      Metal Fabrications

05520      01/22/21      Aluminum Handrails

**Division 6 – Wood and Plastics**

NOT USED

**Division 7 – Thermal and Moisture Protection**

NOT USED

**Division 8 – Doors and Windows**

NOT USED

**Division 9 – Finishes**

09902      01/22/21      Paint and Protective Coatings

**Division 10 – Specialties**

NOT USED

**Division 11 – Equipment**

11321      04/23/21      Catenary Cleaning Mechanism for Bar Rack Screens

**Division 12 – Furnishings**

NOT USED

**Division 13 – Special Construction**

13390      05/28/21      Packaged Control Systems

**Division 14 – Conveying Systems**

NOT USED

**Table of Contents**

---

**Division 15 – Mechanical**

15075	01/22/21	Mechanical Identification
15172	01/22/21	Electrical Motor, High Efficiency, Horizontal Induction, 300 HP and Smaller

**Division 16 – Electrical**

16150	05/28/21	Raceways, Fittings and Supports
16200	05/28/21	Wiring (600 Volts and Below)
16250	05/28/21	Boxes and Cabinets
16540	05/28/21	Field Control Stations
16550	05/28/21	Grounding
16800	05/28/21	Calibration, Testing and Settings

**Division 17 – Instrumentation and Control**

17100	05/28/21	Process Instrumentation and Control System (PICS)
17200	05/28/21	Instrumentation and Control Cabinets and Associated Equipment
17380	05/28/21	Field Instrumentation and Sensing Devices
17600	05/28/21	Distributed Control System

**VOL. 3 of 3    08/2019                    MBE/WBE Procurement Program Package**

**END**



## **SECTION 05010**

### **METALS FOR STRUCTURES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. This Section includes the furnishing and fabrication of various metals for various types of structures shown on PLANS.

##### **1.02 RELATED REQUIREMENTS**

- A. Related work as called for on PLANS or specified in this or other TECHNICAL SPECIFICATION sections.

##### **1.03 REFERENCES**

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.

#### **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)**

ASTM A27/A27M	Standard Specifications for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished
ASTM A36/A36M	Standard Specification for Structural Steel
ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
ASTM A193/A193M	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing or Steel Assemblies
ASTM A525	Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A992 / A992M-00	Standard Specification for Steel for Structural Shapes for use in Building Framing
ASTM B29	Standard Specification for Refined Lead

ASTM B133/B133M	Standard Specification for Copper Rod, Bar, and Shapes
ASTM B152/B152M	Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes
ASTM B308/B308M	Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Shapes

#### **1.04 - 1.11 (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURER(S) (NOT USED)**

### **2.02 MATERIALS AND/OR EQUIPMENT**

- A. Structural Steel:
  - 1. Rolled Wide Flange Shapes: Per ASTM A992/A992M.
  - 2. All other Rolled Shapes: Per ASTM A36/A36M, unless otherwise noted.
- B. Carbon Steel Castings: Per ASTM A27/A27M, Grade 60-30M (Minimum).
- C. Galvanized Sheet Metal: Per ASTM A525, for zinc-coated (galvanized) iron or steel sheets.
- D. Threaded Fasteners
  - 1. Standard Bolts: Per ASTM A307.
  - 2. High-Strength Bolts: Per ASTM A325.
- E. Corrosion-Resisting (Stainless) Steel
  - 1. Plate, Sheet, Strip, Fasteners Where No Welding Required: Per ASTM A167, Type 316 unless noted otherwise.
  - 2. Plate, Sheet, Strip, Fasteners Where Welding Required: Per ASTM A167, Type 316L or unless noted otherwise.
  - 3. Bolts: Type 316 conforming to ASTM A193 with suitable stainless steel nuts and washers.
- F. Copper
  - 1. Sheet, Strip, Plate: Per ASTM B152/B152M, No. 110.
  - 2. Rod, Bar, Shapes: Per ASTM B133/B133M, No. 110.
- G. Lead: Pig lead per ASTM B29.
- H. Aluminum
  - 1. Structural Shapes, Extrusions, Bars, Grating, Stair Treads: Per ASTM B221 and ASTM B308/B308M, Alloy 6061-T6.
  - 2. Gravel Stops: Per ASTM B221, Alloy 6063-T42.
  - 3. Other Items: Per recognized standards.
- I. Galvanizing: Per ASTM A123, ASTM A153, and ASTM A384 as applicable.

### **2.03 - 2.04 (NOT USED)**

## **PART 3 EXECUTION**

**3.01 - 3.10 (NOT USED)**

### **3.11 MEASUREMENT AND PAYMENT**

No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**

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## SECTION 05015

### STAINLESS STEEL FABRICATIONS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Scope: Applies to all stainless steel fabrications as shown on the PLANS. Furnish all plant, labor, supervision, materials, equipment, supplies, tools, and all operations in connection with furnishing, installing, and placing in service stainless steel fabrications.

##### 1.02 RELATED REQUIREMENTS

Other related work as called for on PLANS or specified elsewhere in this or other Technical Specification Sections.

##### 1.03 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

#### AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.2.1                      Square and Hex Bolts and Screws Inch Series

#### AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Section IX              Boiler and Pressure Vessel Code - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

#### AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

ASTM A167                      Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A193                      Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

ASTM A240                      Standard Specification for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels

ASTM A276                      Standard Specification for Stainless Steel Bars and Shapes

**1.04 - 1.05**            (NOT USED)

##### 1.06 SUBMITTALS

- A. Furnish large-scale, dimensioned shop drawings showing plan, elevation, and appropriate cross sections. Show piece marks, sizes, drilling, thickness, joint details, and materials. Furnish chemical and physical material certificates for each heat used during manufacture.
- B. Submit welder qualification certificates.
- C. Submit shop testing certificates.

## **1.07 QUALITY ASSURANCE**

- A. Fabrication dimensions and accuracy of fabrication are Contractor's responsibility.

## **1.08 DELIVERY, STORAGE, AND HANDLING**

- A. Shipping
  - 1. Ship factory fabricated assemblies in the largest sections permitted by carrier regulations, properly match-marked for ease of field erection.
  - 2. Loose parts (nuts and bolts, etc.) are to be shipped in crates that are clearly marked as to contents.
- B. Handling and Unloading
  - 1. Unload and handle equipment in accordance with fabricator's instructions.
  - 2. Transfer of unprotected stainless steel to be accomplished utilizing nylon straps or stainless steel cables to avoid contact with carbon steel components.
- C. Storage
  - 1. Store in an area that will avoid damage due to traffic.
  - 2. Exposure to normal weather conditions is acceptable; however, avoid contact with other materials like carbon steel, aluminum, concrete, and corrosive chemicals.

## **1.09 - 1.11 (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURER(S):** Use materials of domestic manufacture.

### **2.02 MATERIALS AND/OR EQUIPMENT**

- A. General: Materials used in manufacture to be 316L stainless steel unless specifically noted otherwise.
- B. Minimum Material Requirements
  - 1. Stainless Steel Bars and Shapes: ASTM A276
  - 2. Stainless Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, ASTM A240, or ASTM A167
  - 3. Stainless Steel Bolts and Nuts: ASTM 193

### **2.03 FABRICATION**

- A. General:
  - 1. All fabrication to be performed in a fully equipped fabrication shop.
  - 2. Each piece to be marked with an identification mark that corresponds to the shop drawing to facilitate job site assembly.
- B. Welding
  - 1. All welding is to be qualified and certified in accordance with the requirements of the latest edition of ANSI/AWS D1.1 "Structural Welding Code – Steel" published by the American Welding Society.
  - 2. Fabricate utilizing inert argon gas, shielded arc plasma, MIG or TIG welding procedures.
  - 3. Add filler wire to all welds to provide a cross sectional area of weld and metal thickness equal to or greater than the parent metal. Filler wire to be at least one grade higher than the parent metal and of the extra low carbon grade.

4. Rigid jigs and fixtures are to be utilized for holding parts together in proper alignment while welding.
  5. All joints are to be accurately fitted, aligned, and cleaned of foreign material prior to welding.
  6. Grind flush all welds on gasketed surfaces.
- C. Pickle and passivate all welded stainless steel fabrications by using the following procedure.
1. Wire-brush all outside weld area to remove weld splatter. Brushes are to be stainless steel and are to have been used only on stainless steel.
  2. Remove all carbon deposits, greases, and oils by pickling and neutralization to aid the regeneration of a uniform corrosion-resistant chromium oxide film.
    - a. After welding and brushing the weld clean, completely immerse all stainless steel assemblies and parts in a pickling solution of 6% nitric acid and 3% hydrofluoric acid at a temperature of 140 F for a minimum of 15 minutes or until a mild etch is achieved. In lieu of passivation, a glass bead blast will be acceptable.
    - b. Neutralize the pickling solution after cleaning by immersing the assemblies and parts into a solution of tri-sodium phosphate and then rinsing with clean water.

#### **2.04 SOURCE QUALITY CONTROL**

- A. Nuts and Bolts: Per ANSI B 18.2, stainless steel, type and grade to prevent galling.

### **PART 3 EXECUTION**

#### **3.01 - 3.02 (NOT USED)**

#### **3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION**

- A. General Requirements
1. PLANS show sizes, elevations, and general arrangement.

#### **3.04 - 3.10 (NOT USED)**

#### **3.11 MEASUREMENT AND PAYMENT**

No separate measurement and payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**

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## **SECTION 05120**

### **STRUCTURAL STEEL**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. This Section defines the furnishing, fabrication, and installation of various metals for various types of structures and support purposes. The Section includes:
  - 1. Structural steel shapes and plate.
  - 2. Fasteners:
    - a. All thread rods.
    - b. Anchor bolts.
    - c. Assembly bolts.
    - d. Chemical anchors.
    - e. Concrete anchors.
    - f. Concrete inserts.
    - g. Deformed bar anchors.
    - h. Eyebolts.
    - i. Flush shells.
    - j. High strength all thread rods.
    - k. High strength bolts.
    - l. Powder actuated fasteners.
    - m. Sleeve anchors.
    - n. Undercut or similar concrete anchors.
    - o. Welded studs.
  - 3. Isolation sleeves and washers.
  - 4. Thread coating.
  - 5. Welding.

##### **1.02 RELATED REQUIREMENTS**

- A. Other related work as called for on PLANS or specified elsewhere in this or other TECHNICAL SPECIFICATION Sections.

##### **1.03 REFERENCES**

The publications listed below form a part of this Specification to the extent referenced. The publications are referenced to in the text by basic designation only.

#### **AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)**

AISC                                      Specification for Structural Steel Buildings

#### **AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)**

ANSI B212-15                              Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills

#### **AMERICAN WELDING SOCIETY (AWS)**

AWS A5.1                                      Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

AWS A5.17	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
AWS A5.20	Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
AWS D1.1	Structural Welding Code – Steel
AWS D10.4	Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing

#### **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)**

ASTM A 29	Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for
ASTM A 36 / A 36M	Standard Specification for Carbon Structural Steel
ASTM A 53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless
ASTM A 108	Standard Specification for Steel Bars, Carbon, Cold Finished
ASTM A 123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153 / A 153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 193	Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 489	Standard Specification for Carbon Steel Lifting Eyes
ASTM A 490	Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A 496	Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A 500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A 501	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 992 / A 992M	Standard Specification for Structural Steel Shapes
ASTM F 593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F 959	Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners

#### **INTERNATIONAL CODE COUNCIL (ICC)**

#### **INTERNATIONAL BUILDING CODE (IBC)**

IBC AC 01	Acceptance Criteria for Expansion Anchors in Masonry Elements
IBC AC 58	Acceptance Criteria for Adhesive Anchors in Masonry Elements
IBC AC 193	Acceptance Criteria for Mechanical Anchors in Concrete Elements
IBC AC 308	Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

#### **1.04 – 1.05 (NOT USED)**

#### **1.06 SUBMITTALS**

- A. Furnish the following in accordance with Specification Section 01300, "Submittals".
  - 1. Product data
    - a. Post-installed anchors for use in concrete and masonry.
      - (1) Manufacturer's data including catalog cuts showing materials of construction, finishes, and details of installation for each anchor type.
  - 2. Quality control submittals
    - a. Submit shop drawings of members to be fabricated before starting their fabrication.
    - b. Welder's certificates.
    - c. Submit steel fabricator's certification.
  - 3. Test reports
    - a. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.
    - b. Current International Code Council Evaluation Service (ICC-ES) Report for each type of post-installed anchors to be used.
    - c. Concrete anchor installation test report.

#### **1.07 QUALITY ASSURANCE**

- A. Qualifications:
  - 1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
  - 2. Steel fabricators shall be certified by the AISC or other certification as recognized and accepted by the local building official having jurisdiction.
  - 3. Notify ENGINEER 24 hours minimum before starting shop or field welding.

4. ENGINEER may check materials, equipment, and qualifications of welders.
  5. Remove welders performing unsatisfactory Work, or require to requalify.
  6. ENGINEER may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
  7. CONTRACTOR shall bear costs of retests on defective welds.
  8. CONTRACTOR shall also bear costs in connection with qualifying welders.
- B. Certification:
1. Steel fabricators shall be certified by the AISC or other certification acceptable to the local building official having jurisdiction.
- C. Concrete anchor installation test:
1. Prior to installation or use of concrete anchors, perform the following test:
    - a. Furnish not less than four of each type proposed for use, and install anchors in a test block of concrete to specified embedment length.
    - b. Furnish and install one 5/8-inch nut on each concrete anchor and tighten each with an applied torque of 10 foot-pounds.
    - c. Loosen each nut and then retighten with an applied torque load of 10 foot-pounds.
    - d. Visible evidence of turning by a concrete anchor will be cause for ENGINEER to reject concrete anchors.

#### 1.08 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.
- B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

#### 1.09 – 1.11 (NOT USED)

### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS (NOT USED)

#### 2.02 MATERIALS AND/OR EQUIPMENT

- A. Unless otherwise specified or Indicated on the Drawings, materials shall conform to the following:

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A 36 / A 36M	--
Rolled W and WT shapes	A 992 / A 992M	Grade 50
Hollow structural sections (HSS): Round, square, or rectangular	A 500	Grade B
Tubing, hot-formed	A 501	--
Round HSS	A 500	Grade B
Steel pipe	A 53	Grade B
Stainless steel		

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
* Use Type 304L if material will be welded.		
** Use Type 316L if material will be welded.		

- B. Where stainless steel is welded, use low-carbon stainless steel.
- C. General: Furnish threaded fasteners, except high strength bolts, with flat washers, and self-locking nuts, or lock washers and nuts.
1. Bolt heads and nuts: Hex-type.
  2. Bolts, nuts, and washers: Of domestic manufacture.
  3. Where bolts, including anchor bolts, nuts, washers, and similar fasteners are specified to be galvanized, galvanize in accordance with ASTM A 153 / A 153M.
- D. All thread rods:
1. Type 316 Stainless Steel in accordance with ASTM F 593 for use in wet and moist locations, including:
    - a. Water-containing structures:
      - (1) Below and at water level.
      - (2) Above water level:
        - (a) Below top of walls of water-containing structures.
        - (b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
      - (3) Dry side of walls of water-containing structures.
    - b. Pump bases.
  2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
  3. ASTM A 36 / A 36M meeting the mechanical requirements of ASTM A 307. Hot-dip galvanize for galvanized assemblies and for applications other than those specified.
- E. All thread rods bonded in holes drilled in concrete with epoxy: As specified in Paragraph 2.02.A and as indicated on the PLANS.
- F. Anchor bolts:
1. Anchor bolts, nuts, and washers: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
    - a. Water-containing structures:
      - (1) Below and at water level.
      - (2) Above water level:
        - (a) Below top of walls of water-containing structures.
        - (b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
      - (3) Dry side of walls of water-containing structures.
    - b. Pump bases.
  2. Anchor bolts, nuts, and washers: Type 304 or Type 316 stainless steel for fastening aluminum to concrete or steel.
  3. Anchor bolts, nuts, and washers: Hot-dip galvanized ASTM A 307 steel bolt or hot-dip galvanized ASTM A 36 / A 36M steel, for applications other than those specified.

- G. Assembly bolts:
1. Bolts, nuts, and washers for wood baffles, collectors, and other field-assembled construction: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
    - a. Water-containing structures:
      - (1) Below and at water level.
      - (2) Above water level:
        - (a) Below top of walls of water-containing structures.
        - (b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
        - (c) Dry side of walls of water-containing structures.
    - b. Pump bases.
  2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
  3. Hot-dip galvanized ASTM A 307 steel for galvanized assemblies and for applications other than those specified.
- H. Chemical anchors:
1. All-thread rods shall be either ASTM A 36 / A 36M steel or stainless steel.
  2. Hot-dip galvanize or zinc plate ASTM A 36 / A 36M steel all-thread rods.
  3. Stainless steel all-thread rod shall conform with ASTM F 593 and shall be used for corrosive conditions where indicated on the PLANS.
  4. All-thread rods used with the adhesive capsule shall have chisel points and shall be free of oil or coatings that may reduce bond.
  5. Do not use chemical anchors to resist tension in overhead positions.
  6. Chemical anchors for anchorage to concrete:
    - a. Chemical anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 308 for cracked concrete.
    - b. Manufacturers: One of the following or approved equal:
      - (1) Simpson SET-XP (ICC ESR-250B)
  7. Chemical anchors for anchorage to masonry (solid or solid grouted):
    - a. Chemical anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 58.
    - b. Manufacturers: One of the following or approved equal:
      - (1) Simpson SET (ICC ESR-1772)
- I. Concrete mechanical and screw anchors:
1. Expansion and screw anchors anchorage to concrete:
    - a. Concrete anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 193 for cracked concrete.
    - b. Manufacturers: One of the following or approved equal:
      - (1) Simpson STRONG-BOLT (ICC ESR-1771) or TITEN HD (ICC ESR-2713)
      - (2) Hilti KWIK-BOLT TZ (ICC ESR-1971)
  2. Expansion and screw anchors anchorage to masonry:
    - a. Concrete anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 01.
    - b. Manufacturers: One of the following or approved equal:
      - (1) Simpson WEDGE-ALL (ICC ESR-1396) or TITEN HD (ICC ESR-1056)
  3. Concrete anchor's integral threaded stud, wedge, washer, and nut: Type 304 or Type 316 stainless steel in accordance with ASTM F 593. For use in wet and moist locations, including:
    - a. Water-containing structures:
      - (1) Below and at water level.

- (2) Above water level:
        - (a) Below top of walls of water-containing structures.
        - (b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
      - (3) Dry side of walls of water-containing structures.
    - b. Pump bases.
  - 4. Concrete anchor's integral threaded stud, wedge, washer, and nut: Type 304 or 316 stainless steel in accordance with ASTM F 593 for fastening aluminum to concrete or steel.
  - 5. Concrete anchor's integral threaded stud, wedge, washer, and nut: Hot-dip galvanized carbon steel, for applications other than those specified.
  - 6. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
- J. Concrete inserts: 1 piece, hot-dip galvanized, integrally hot forged unit fabricated from steel meeting ASTM A 29 Hot Rolled Grade 1045 requirement. Manufacturers: One of the following or approved equal:
- 1. Dayton Superior, F-54 Ductile Embedded Insert.
- K. Deformed bar anchors: In accordance with ASTM A 496:
- 1. Manufacturers: One of the following or approved equal:
    - a. Nelson Stud Welding Company, D2L Deformed Bar Anchors.
    - b. Stud Welding Products, DBA (Deformed Bar) Anchors.
- L. Eyebolts:
- 1. Welded or forged, when manufactured of materials other than carbon steel.
  - 2. Having geometric and strength characteristics of eyebolts specified in ASTM A 489, Type 1. The strength characteristics include proof load requirements, breaking strength requirements, tensile strength requirements, bend test, and impact strength.
- M. Flush shells:
- 1. Manufacturers: One of the following or approved equal:
    - a. ITW Red Head, Multi-Set II Drop-In.
    - b. Hilti Incorporated, HDI Drop-In.
  - 2. Bolts, flush shells, threaded rods, washers, and nuts: Type 303 stainless steel in accordance with ASTM F 593.
- N. High strength all thread rods: In accordance with ASTM A 193, Grade B7, hot-dip galvanized.
- O. High strength bolts: High strength bolts, nuts, and hardened flat washers shall be in accordance with ASTM A 325 or ASTM A 490, as indicated on the PLANS.
- P. Powder actuated fasteners:
- 1. For installation in concrete or steel: Zinc coated, heat-treated, alloy steel.
  - 2. Fasteners not sufficiently protected against corrosion from exposure to corrosive conditions: Coat as necessary to make suitable for such conditions.
  - 3. Pins: Furnish with head or threaded stud capable of transmitting loads to shank.
  - 4. Pins connected to steel: Furnish with longitudinal serrations around circumference of shank.
- Q. Sleeve anchors:
- 1. Sleeve anchors for anchorage to concrete:
    - a. Sleeve anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 193 for cracked concrete.

- b. Manufacturers: One of the following or approved equal:
      - (1) Hilti HSL-3 (ICC ESR-1545)
  - 2. Sleeve anchors for anchorage to masonry:
    - a. Sleeve anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 01.
    - b. Manufacturers: One of the following or approved equal:
      - (1) Simpson SLEEVE-ALL
  - 3. Use stainless material for aluminum and stainless attachments and carbon steel for steel attachments.
  - 4. For use in wet and moist locations, including locations listed below. Use Type 304 stainless steel in accordance with ASTM F 593 for sleeve anchor's internal bolt, expansion sleeve, extension sleeve, and washer. Use Type 303 stainless steel in accordance with ASTM F 593 for sleeve anchors expansion cone.
    - a. Water-containing structures:
      - (1) Below and at water level.
      - (2) Above water level:
        - (a) Below top of walls of water-containing structures.
        - (b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
      - (3) Dry side of walls of water-containing structures.
    - b. Pump bases.
  - 5. For fastening aluminum to concrete or steel, use Type 304 stainless steel in accordance with ASTM F 593 for sleeve anchor's internal bolt, expansion sleeve, extension sleeve. Use Type 303 stainless steel in accordance with ASTM F 593 for sleeve anchor's expansion cone.
  - 6. For applications other than those specified above, use hot-dip galvanized carbon steel for sleeve anchor's internal bolt, expansion sleeve, expansion cone, extension sleeve, and washer.
  - 7. The sleeve anchor shall have a nylon compression ring which compresses to ensure that the material being fastened is tightly secured against the concrete.
  - 8. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
- R. Undercut concrete anchors:
  - 1. Materials: In accordance with ASTM A 193, Grade B7. hot-dip galvanized.
  - 2. Manufacturers: One of the following or approved equal:
    - a. Simpson TORQ-CUT anchors
    - b. Hilti HDA Undercut anchors
- S. Welded studs:
  - 1. ASTM A 108 with 50,000-pounds per square inch minimum yield strength, and 60,000-pounds per square inch minimum tensile strength.
  - 2. Headed studs: Manufacturers: One of the following or approved equal:
    - a. Nelson Stud Welding Company, S3L Shear Connectors or H4L Concrete Anchors.
    - b. Stud Welding Products, Headed Concrete Anchors or Shear Connectors.
- T. Isolating Sleeves and Washers:
  - 1. Manufacturers: One of the following or approved equal:
    - a. Central Plastics Company, Shawnee, Oklahoma.
    - b. Corrosion Control Products, PSI Inc., Gardena, CA.
  - 2. Sleeves: Mylar, 1/32 inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
    - a. 1 sleeve required for each bolt.



3. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter.
  - a. Proper size to fit bolts. Two insulating washers are required for each bolt.
  - b. Two 1/8-inch thick steel washers for each bolt.
4. G3 Phenolic:
  - a. Thickness: 1/8 inch.
  - b. Base material: Glass.
  - c. Resin: Phenolic.
  - d. Water absorption: 2 percent.
  - e. Hardness (Rockwell): 100.
  - f. Dielectric strength: 450 volts per mil.
  - g. Compression strength: 50,000 pounds per square inch.
  - h. Tensile strength: 20,000 pounds per square inch.
  - i. Maximum operating temperature: 350 degrees Fahrenheit.
- U. Galvanizing Surface Repair: Manufacturers: One of the following or approved equal:
  1. Galvinox.
  2. Galvo-Weld.
- V. Thread Coating: Manufacturers: One of the following or approved equal:
  1. Never Seez Compound Corporation, Never-Seez.
  2. Oil Research, Inc., WLR No. 111.
- W. Supplementary Parts: Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the PLANS.

## 2.03 FABRICATION

- A. Shop assembly:
  1. Fabricate structural steel in conformance with AISC "Specification for the Structural Steel Buildings - Allowable Stress Design and Plastic Design," unless otherwise specified or modified by applicable regulatory requirements.
  2. Where anchors, connections, or other details of structural steel are not specifically indicated on the PLANS or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
  3. For Structural members such as W shapes, S shapes, channels, angles, and similar members not available in quantity, size, and type of stainless steel specified or indicated on the PLANS.
    - a. Fabricate by welding together pieces of low carbon stainless steel plate, such as Type 316L.
    - b. Make full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as members indicated on the PLANS.
  4. Where galvanizing is required, hot-dip galvanize structural steel after fabrication in accordance with ASTM A 123:
    - a. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by ENGINEER.
    - b. Restraighten galvanized items that bend or twist during galvanizing.
  5. Round off sharp and hazardous projections and grind smooth.
  6. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
  7. Take responsibility for correct fitting of all metal work.

## 2.04 SOURCE QUALITY CONTROL (NOT USED)

## **PART 3 EXECUTION**

### **3.01 GENERAL (NOT USED)**

### **3.02 PREPARATION**

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION**

- A. General:
  - 1. Fabricate structural and foundry items to true dimensions without warp or twist.
  - 2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
  - 3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
  - 4. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
  - 5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
  - 6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
  - 7. Erect structural steel in conformance with AISC "Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design," unless otherwise specified or modified by applicable regulatory requirements.
  - 8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
  - 9. Round off sharp or hazardous projections and grind smooth.
  - 10. Paint or coat steel items as specified in Section 09902.
- B. Welding - General:
  - 1. Make welds full penetration type, unless otherwise indicated on the PLANS.
  - 2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.
- C. Welding stainless steel:
  - 1. General: Comply with AWS D1.1.
    - a. Perform with electrodes and techniques in accordance with AWS D10.4.
- D. Welding carbon steel:
  - 1. General: Comply with AWS D1.1:
    - a. Weld ASTM A 36 / A 36M and A 992 / A 992M structural steel, ASTM A 500 and A 501 structural tubing, and ASTM A 53 pipe with electrodes conforming to AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
      - (1) Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

- E. Interface with other products:
1. Where steel fasteners come in contact with aluminum or other dissimilar metals, bolt with stainless steel bolts and separate or isolate from dissimilar metals with isolating sleeves and washers.
    - a. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
- F. Fasteners:
1. General:
    - a. Install bolts, including anchor bolts and concrete anchors, to project 2 threads minimum, but 1/2 inch maximum beyond nut.
    - b. Unless otherwise specified, tighten bolts, including anchor bolts and concrete anchors, to the "snug-tight" condition, defined as tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.
  2. All thread rods bonded in drilled holes in concrete with epoxy: As specified in Contract and as indicated on the PLANS.
  3. Anchor bolts:
    - a. Cast-in-place when concrete is placed.
    - b. Accurately locate anchor bolts embedded in concrete with bolts perpendicular to surface from which they project.
    - c. Do not allow anchor bolts to touch reinforcing steel.
    - d. Where anchor bolts are within 1/4 inch of reinforcing steel, isolate with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
    - e. In anchoring machinery bases subject to heavy vibration, use 2 nuts, with 1 serving as a locknut.
    - f. Where bolts are indicated on the PLANS for future use, first coat thoroughly with nonoxidizing wax, then turn nuts down full depth of thread and neatly wrap exposed thread with waterproof polyvinyl tape.
    - g. Furnish anchor bolts with standard hex bolt head or an equivalent head acceptable to ENGINEER unless otherwise indicated on the PLANS. "L" or "J" anchor bolts are not equivalent to an anchor bolt with a hex bolt head.
    - h. Minimum anchor bolt embedment: 10-bolt diameters, unless longer embedment is indicated on the PLANS.
    - i. Where indicated on the PLANS, set anchor bolts in metal sleeves having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long. Fill sleeves with grout when a machine or other equipment is grouted in place.
    - j. Anchor bolts may be cast in concrete in lieu of using concrete anchors.
  4. Chemical anchors:
    - a. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
    - b. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
    - c. Drilling holes:
      - (1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
      - (2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
    - d. Hole drilling equipment:
      - (1) Electric or pneumatic rotary type with light or medium impact.

- (2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
  - (3) Hollow drills with flushing air systems are preferred. Air shall be free of oil, water, or other contaminants which will reduce bond.
  - (4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- e. Hole diameter:
  - (1) As recommended by chemical anchor cartridge manufacturer.
- f. Install all thread rods to depth, spacings, and locations as indicated on the PLANS.
- g. Cleaning holes:
  - (1) Insert long air nozzle into hole and blow out loose dust. Use air which is free of oil, water, or other contaminants which will reduce bond.
  - (2) Use a stiff bristle brush to vigorously brush hole to dislodge compacted drilling dust.
  - (3) Repeat step 1.
  - (4) Repeat above steps as required to remove drilling dust or other material which will reduce bond. The hole shall be clean and dry.
- h. Cleaning all thread rods:
  - (1) Degrease over embedment length. The all thread rods shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
- 5. Concrete anchors:
  - a. Do not use concrete anchors in lieu of anchor bolts.
  - b. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
  - c. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
  - d. Minimum embedment lengths:

<b>Diameter Inches</b>	<b>Embedment Length Inches</b>
1/4	2
3/8	2-1/2
1/2	4-1/8
5/8	4-1/2
3/4	6-1/2

- e. Drilling holes:
  - (1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
  - (2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
  - (3) Remove dust and debris from hole using compressed air.
- f. Hole drilling equipment:
  - (1) Electric or pneumatic rotary type with light or medium impact.
  - (2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
  - (3) Hollow drills with flushing air systems are preferred.

- (4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- 6. Deformed bar anchors:
  - a. Butt weld with automatic stud welding gun as recommended by manufacturer.
  - b. Ensure butt weld develops full strength of the anchor.
- 7. Flush shells:
  - a. Use only where specifically indicated on the Drawings.
  - b. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
  - c. Accurately locate and set perpendicular to surfaces from which they project.
  - d. Drilling holes:
    - (1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
    - (2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
    - (3) Remove dust and debris from hole using compressed air.
  - e. Hole drilling equipment:
    - (1) Electric or pneumatic rotary type with light or medium impact.
    - (2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
    - (3) Hollow drills with flushing air systems are preferred.
    - (4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- 8. High strength bolts:
  - a. Consider connections with high strength bolts to be slip critical structural connections, unless otherwise indicated on the PLANS.
  - b. Connections with high strength bolts shall conform to AISC Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.
  - c. Furnish hardened flat washer:
    - (1) Under element, nut, or bolt head, turned in tightening.
    - (2) On outer plies for short slotted holes.
  - d. Verify adequate tightening of bolts by means of tension indicator washers placed as indicated in ASTM F 959, Figure 1.
- 9. Powder actuated fasteners: Use powder actuated fasteners only for applications indicated on the PLANS or specified.
- 10. Sleeve anchors:
  - a. Do not use sleeve anchors in lieu of anchor bolts.
  - b. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
  - c. The sleeve anchor bolt shall be removable and the expansion sleeve shall be flush with the concrete surface when installed.
  - d. Accurately locate sleeve anchors and set perpendicular to surfaces from which they project.
  - e. Minimum embedment lengths:

Diameter Inches	Embedment Length Inches
1/4	1-3/4
3/8	2-1/2
1/2	3-1/2
5/8	4
3/4	4-1/2

- f. Drilling holes:
  - (1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
  - (2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
  - (3) Remove dust and debris from hole using compressed air.
- g. Hole drilling equipment:
  - (1) Electric or pneumatic rotary type with light or medium impact.
  - (2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
  - (3) Hollow drills with flushing air systems are preferred.
  - (4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- 11. Welded studs:
  - a. Butt weld with automatic stud welding gun as recommended by the manufacturer.
  - b. Ensure butt weld develops full strength of the stud.
- 12. Undercut anchors:
  - a. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
  - b. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
  - c. Drilling holes:
    - (1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
    - (2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
  - d. Hole drilling equipment:
    - (1) Electric or pneumatic rotary type with light or medium impact.
    - (2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
    - (3) Hollow drills with flushing air systems are preferred.
    - (4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
    - (5) Undercut bottom of hole using cutting tools manufactured for this purpose by undercut anchor manufacturer.

**3.04 – 3.10 (NOT USED)**

### **3.11 MEASUREMENT AND PAYMENT**

Unless otherwise indicated, no separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**

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## SECTION 05500

### METAL FABRICATIONS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section Includes:
  - 1. Aluminum grating stair tread.
  - 2. Aluminum stair nosing.
  - 3. Cast Iron stop plank grooves
  - 4. Concrete inserts.
  - 5. Ladders.
  - 6. Metal gratings.
  - 7. Metal tread plate.
  - 8. Preformed channel pipe supports.
  - 9. Stairs.
  - 10. Miscellaneous metals.
  - 11. Associated accessories to the above items.

##### 1.02 RELATED REQUIREMENTS

- A. Other related work as called for on the PLANS and specified elsewhere in this or other TECHNICAL SPECIFICATIONS.

##### 1.03 REFERENCES

The publications listed below for a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

#### ALUMINUM ASSOCIATION (AA)

M12-C22-A41 Aluminum Finishes.

#### AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO Standard Specifications for Highway Bridges.

#### AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M	Standard Specification for Structural Steel.
ASTM A 48	Standard Specification for Grey Iron Castings.
ASTM A 53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
ASTM A 123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
ASTM A 240	Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
ASTM A 269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes.
ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
ASTM A 325	Standard Specification for High-Strength Bolts for Structural Steel Joints.
ASTM A 489	Standard Specification for Carbon Steel Lifting Eyes.

ASTM A 490	Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength.
ASTM A 500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
ASTM A 501	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
ASTM A 569	Standard Specification for Steel, Carbon (0.15 Maximum, Percent) Hot-Rolled Sheet and Strip Commercial Quality.
ASTM A 570/A 570M	Standard Specification for Steel, Sheet and Strip, Carbon. Hot-Rolled, Structural Quality.
ASTM A 635/A 635M	Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled.
ASTM A 653/A 653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
ASTM A 992/A 992M	Standard Specification for Structural Steel Shapes.]
ASTM B 209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
ASTM B 221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
ASTM B 308	Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
ASTM B 429	Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
ASTM F 593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.

#### **AMERICAN WELDING SOCIETY (AWS)**

AWS	Standard Symbols for Welding, Brazing, and Nondestructive Examination.
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#### **NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)**

NAAMM	Metal Finishes Manual.
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#### **OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)**

OSHA	Code of Federal Regulations (CFR), Title 29, Labor, Pt. 1900-1990.
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### **1.04 – 1.05 (NOT USED)**

### **1.06 SUBMITTALS**

- A. Furnish the following in accordance with Specification Section 01300, "Submittals".
  1. Product Data:
    - a. Aluminum grating stair tread.
    - b. Aluminum stair nosing.
    - c. Cast Iron stop plank grooves
    - d. Manhole steps.
    - e. Metal Grating.
  2. Shop Drawings:
    - a. Ladders.
    - b. Metal grating.
    - c. Metal tread plate.
    - d. Stairs.

- e. Miscellaneous metals.
- 3. Quality Control Submittals:
  - a. Design data and calculations. Stairs and ladders to include drawings and calculations, signed and sealed by ENGINEER registered in the State of Texas.
  - b. Test Reports:
  - c. Gratings:
    - 1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
    - 2) Reports of tests performed.

## 1.07 – 1.11 (NOT USED)

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS (NOT USED)

### 2.02 MATERIALS AND/OR EQUIPMENT

- A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals shall conform with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
<b>Cast Iron</b>		
Cast Iron	A 48	Class 40B
<b>Steel</b>		
Galvanized sheet iron or steel	A 653	Coating G90
Black steel, sheet or strip	A 569 A 570	--
Coil (plate)	A 635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A 36	--
Rolled W shapes	A 992	Grade 50
Standard bolts, nuts, and washers	A 307	--
High strength bolts, nuts, and hardened flat washers	A 325 A 490	--
Eyebolts	A 489	Type 1
Tubing, cold-formed	A 500	--
Tubing, hot-formed	A 501	--
Steel pipe	A 53	Grade B
<b>Stainless steel</b>		
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
<b>Aluminum</b>		
Flashing sheet aluminum	B 209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B 209	Alloy 6061-T6
Structural aluminum	B 209 B 308	Alloy 6061-T6
Extruded aluminum	B 221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
  2. Where stainless steel is welded, use low-carbon stainless steel.
- B. Aluminum Grating Stair Tread:
1. Manufacturers: One of the following or equal:
    - a. IKG Borden Industries, Aluminum Grating Stair Tread with Mebac nosing.
    - b. McNichols Co., Type A-Standard with Corrugated Angle Nosing
  2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers.
  3. Size:
    - a. Tread Width: To equal tread spacing plus 1-inch minimum
    - b. Tread Length: Length to suit stringer to stringer dimension indicated on the PLANS.
    - c. Depth: 1-3/4 inches.
  4. Bolts: Type 304 stainless steel.
- C. Aluminum Stair Nosing:
1. Manufacturers: One of the following or equal:
    - a. Wooster Products, Inc., Type 101 Nosing.
    - b. American Safety Tread Co., Inc., Style 801 Nosing.
  2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
  3. For installation in cast-in-place stairs.
  4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.
- D. Cast Iron Stop Plank Grooves:
1. Manufacturers: One of the following or equal:
    - a. Neenah Foundry Company, R-7500 Series, Type A.
    - b. McKinley Iron Works, Type L.
  2. Size: 2-inch wide groove opening by 1-1/2 inch deep, unless otherwise indicated on the PLANS.
  3. Recess groove with the cast iron surface of the groove set flush with the concrete surface.
- E. Concrete Inserts:
1. Reference Contract Specifications for Concrete inserts for supporting pipe and other applications.

- F. Ladders:
1. General:
    - a. Type: Safety type conforming to local, State, and Occupational Safety and Health Administration standards as minimum. Furnish guards for ladder wells.
    - b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the PLANS.
  2. Aluminum Ladders:
    - a. Materials: 6063-T5 aluminum alloy.
    - b. Rungs:
      - 1) Capable of withstanding 1,000-pound load without failure.
    - c. Side Rails: Minimum 4-inch by 1/2-inch flat bars.
    - d. Fabrication:
      - 1) Welded construction, of size, shape, location, and details indicated on the PLANS.
      - 2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and Occupational Safety and Health Administration requirements.
    - e. Fall Prevention System: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying Occupational Safety and Health Administration safe climbing requirements:
      - 1) Manufacturers: One of the following or equal:
        - a) North Consumer Products, Saf-T-Climb.
        - b) Swager Communications, Climbers Buddy System.
- G. Manhole Steps:
1. Type 316 stainless steel, of size, shape, and spacing indicated on the PLANS.
- H. Metal Gratings:
1. General:
    - a. Fabricate grating to cover areas indicated on the PLANS.
    - b. Unless otherwise indicated on the PLANS, grating over an opening shall cover entire opening.
    - c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    - d. Band Ends of Grating and Edges of Cutouts in Grating:
      - 1) End Banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
      - 2) Cutout Banding: Full-height of grating.
      - 3) Use banding of same material as grating.
      - 4) Panel Layout: Enable installation and subsequent removal of grating around protrusions or piping.
      - 5) Openings 6 Inches and Larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
      - 6) Openings Smaller than 6 Inches: Locate opening at edge of single panel.
      - 7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to ENGINEER.
      - 8) Fabricate grating in units of maximum 50 pounds each.
    - e. When requested by ENGINEER, test 1 section of each size grating for each span length involved on the job under full load:
      - 1) Furnish a suitable dial gauge for measuring deflections.
    - f. Grating shall be galvanized steel, unless otherwise specified or indicated on the PLANS.

2. Aluminum Grating:
  - a. Material for Gratings, Shelf Angles, and Rebates: 6061-T6 or 6063-T6 aluminum alloy, except cross bars may be 6063-T5 aluminum alloy.
  - b. Shelf Angle Concrete Anchors: Type 304 or Type 316 stainless steel.
  - c. Grating Rebate Rod Anchors: 6061-T6 or 6063-T6 aluminum alloy.
  - d. Bar Size and Spacing: As determined by manufacturer to enable grating to support design load.
  - e. Design Live Load: A minimum of 150 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
  - f. Maximum Fiber Stress for Design Load: 12,000 pounds per square inch.
  - g. Maximum Deflection Due to Design Load: 1/240 of grating clear span.
  - h. Maximum Spacing of Main Grating Bars: 1-1/8 inches clear between bars.
  - i. Minimum Grating Height: 1-1/2 inches.
  - j. Manufacturers: One of the following or equal:
    - 1) IKG Borden Industries, grooved Galok Aluminum I-Bar.
    - 2) Seidelhuber Metal Products, Inc., grooved I-Bar.
3. Steel Gratings:
  - a. Hot-dip galvanized in accordance with ASTM A 123.
  - b. Bar Size and Spacing: As determined by the manufacturer to support design load.
  - c. Design Live Load: A minimum of 150 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
  - d. Maximum Fiber Stress for Design Load: 18,000 pounds per square inch.
  - e. Maximum Deflection Under Design Load: 1/240 of grating clear span.
  - f. Bar Spacing: Maximum of 1-1/8 inches clear between bars.
  - g. Manufacturers: One of the following or equal:
    - 1) McNichols Company.
    - 2) IKG Borden Industries, IKG Weldforged.
    - 3) Seidelhuber Metal Products, Inc., Type 19W4.
4. Heavy-Duty Steel Grating:
  - a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
  - b. Hot-dip galvanized after fabrication in accordance with ASTM A 123.
  - c. Manufacturers: One of the following or equal:
    - 1) McNichols Company.
    - 2) Reliance Steel Products Company, Heavy-Duty Steel Grating.
    - 3) Seidelhuber Metal Products, Inc., equivalent product.
- I. Metal Tread Plate:
  1. Plate having a raised figured pattern on 1 surface to provide improved traction.
- J. Preformed Channel Pipe Supports:
  1. Preformed channel pipe supports for pipe supports and other applications are specified in Contract.
- K. Stairs:
  1. Aluminum Stairs:
    - a. Stringers: 6061-T6 aluminum alloy.
    - b. Stair Treads:
      - 1) Aluminum of same type specified under Aluminum Grating.
      - 2) Of sizes indicated on the PLANS, and 1-3/4 inch minimum depth with cast abrasive type nosings.
    - c. Handrails and Guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Non-welded Pipe).

- d. Fasteners: Type 304 or Type 316 stainless steel.
- 2. Steel Stairs:
  - a. Ships ladders shall conform to local, State, and Occupational Safety and Health Administration Standards as minimum.
  - b. Stringers: Structural steel channels or plates.
  - c. Treads: Open type attached to stringers with support angles and clips:
    - 1) Borden, "Welded Tread" with Allgrip nosing.
  - d. Railings: Aluminum per related Specification Section.
  - e. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
  - f. Finish: Hot-dip galvanized in accordance with ASTM A 123.
- L. Miscellaneous Metal:
  - 1. Miscellaneous Aluminum: Fabricate aluminum products, not covered separately herein, in accordance with the best practices of the trade and field assemble by riveting or bolting. Do not weld or flame cut.
  - 2. Miscellaneous Cast Iron:
    - a. General:
      - 1) Tough, gray iron, free from cracks, holes, swells, and cold shuts.
      - 2) Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
      - 3) Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the PLANS.
  - 3. Miscellaneous Stainless Steel:
    - a. Provide miscellaneous stainless steel items not specified herein as indicated on the PLANS or specified elsewhere. Fabricate and install in accordance with the best practices of the trade.
  - 4. Miscellaneous Structural Steel:
    - a. Provide miscellaneous steel items not specified herein as indicated on the PLANS or specified elsewhere. Fabricate and install in accordance with the best practices of the trade.

## **PART 3 EXECUTION**

### **3.01 GENERAL (NOT USED)**

### **3.02 PREPARATION**

- A. Verification of Conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

### **3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION**

- A. General: Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
- B. Aluminum Stair Nosing:
  - 1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
  - 2. Omit stair nosings where concrete is submerged.
  - 3. Coat aluminum surfaces in contact with concrete as specified in Section 09902.
  - 4. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step approximately 3 inches from each stair edge.
- C. Cast Iron Stop Plank Grooves:
  - 1. Recess stop plank grooves with cast iron surfaces of groove set flush with concrete surface.

- D. Ladders:
1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
  2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
  3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
  4. Erect rail straight, level, plumb, and true to position indicated on the Drawings. Correct deviations from true line or grade which are visible to the eye.
- E. Manhole Steps:
1. Space as indicated on the PLANS.
- F. Metal Gratings:
1. General:
    - a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
    - b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
    - c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
    - d. Install angle stops at ends of grating.
    - e. Installed grating shall not slide out of rebate or off support.
    - f. Weld stops in place, unless otherwise specified or indicated on the PLANS.
    - g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
  2. Aluminum Grating:
    - a. Coat surfaces of aluminum shelf angles, rebates, and rod anchors in contact with concrete with coal tar epoxy.
    - b. Aluminum Grating: Support on aluminum shelf angles or rebates.
  3. Steel Grating:
    - a. Support on hot-dip galvanized structural steel shelf angles or rebates.
  4. Heavy-Duty Steel Grating:
    - a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
    - b. Use for roadways, traffic areas, and where indicated on the PLANS.
- G. Stairs:
1. General:
    - a. Install guard railings around stair wells as indicated on the PLANS or specified.

**3.04 – 3.10 (NOT USED)**

### **3.11 MEASUREMENT AND PAYMENT**

Unless otherwise indicated, no separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**



## **SECTION 05520**

### **ALUMINUM HANDRAILS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

This Section includes the fabrication, furnishing, and installation of aluminum handrails, complete in place, at locations shown on PLANS.

##### **1.02 RELATED REQUIREMENTS (NOT USED)**

##### **1.03 REFERENCES**

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.

#### **ALUMINUM ASSOCIATION (AA)**

ASD-1	Aluminum Standards and Data
DAF-45	Designation System for Aluminum Finishes
SAA-46	Standards for Anodized Architectural Aluminum

#### **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)**

ASTM A193/A193M	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service
ASTM B429	Standard Specification for Aluminum All Extruded Structural Pipe and Tube
ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

#### **AMERICAN WELDING SOCIETY (AWS)**

AWS D1.2	Structural Welding Code Aluminum
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#### **OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)**

29 CFR 1910	OSHA Regulation Safety and Health Standards for General Industry
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#### **INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)**

IBC	International Building Code
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##### **1.04 DEFINITIONS**

Plans use the terms handrail and guardrail to refer to the railing system defined by this Specification and standard detail drawings.

##### **1.05 SYSTEM DESCRIPTION (NOT USED)**

## **1.06 SUBMITTALS**

Submit the following in accordance with Specification Section 01300, "Submittals".

- A. Product data for materials used.
- B. Complete shop drawings showing handrail locations, railings, posts, splice locations and expansion joint locations. Also include manufacturer's details for connections, anchorage, splices, expansion joints, gates and other pertinent data.
- C. Design calculations showing that the material meets or exceeds the allowable working stress under the applied loading conditions. Test reports may be used to complement the design calculations. Design calculations to be sealed by a Professional Engineer licensed in the State of Texas.
- D. Field layout of fabricated sections to ensure proper fit during erection, after fabrication and finishing, and prior to shipment.
- E. Certificate of Conformance as required in Paragraph 1.07 – Quality Assurance.

## **1.07 QUALITY ASSURANCE**

- A. All design computations and detailed drawings are to be prepared by or under the direct supervision of a Professional Engineer licensed in the State of Texas. Provide a certificate signed and sealed by same engineer stating that the computations and drawings are in conformance with specified design criteria.
- B. Provide handrail system complying with International Building Code and OSHA Regulations.

## **1.08 DELIVERY, STORAGE AND HANDLING**

- A. Deliver handrail to jobsite with sufficient protection to ensure arrival in acceptable and undamaged condition.
- B. Store handrails on level supports above ground, not in contact with dissimilar metals. Protect to prevent damage and exposure from elements until erected. Replace or repair damaged sections at no additional cost to OWNER.

## **1.09 – 1.11 (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURER(S)**

- A. Manufacturer: Products of the following manufacturers, provided they comply with requirements of the Contract Documents, will be among those considered acceptable, or an approved equal.
  - 1. Hollaender Railing Systems (Interna-Rail);
  - 2. Thompson Fabrication Co. (TUFrail); and

## 2.02 MATERIALS AND/OR EQUIPMENT

### A. General

1. Handrail shall be the product of a company normally engaged in the manufacture of pipe railing.
2. Handrail shall conform to requirements of OSHA 1910.23 and applicable building code. Local building code in Austin, TX is the International Building Code.
3. Handrail and posts to be fabricated from 1½-inch nominal diameter 6063-T6 or 6061-T6 aluminum pipe, Schedule 40 minimum conforming to ASTM B429. Exposed aluminum surface to be 0.7-mil thick clear anodized finish, per Aluminum Association Designation M10-C22-A41.
4. Handrail to be 42 inches high; stair handrail to be 34 inches high, unless otherwise noted on PLANS. Centerlines of posts and handrails to be in same plane. Locate intermediate rails as shown on PLANS.
5. Unless shown otherwise in PLANS, post spacing not to exceed 5 feet for horizontal handrail and 4 feet for stair handrail (measured horizontally). The manufacturer must reduce the post spacing and/or add dowels, as required to meet the loading requirements.
6. Provide a 4-inch-high extruded aluminum toe plate that attaches to the posts with clamps that will allow for horizontal expansion and contraction between posts. Toe plate to have not more than 1/4-inch clearance above floor level and provided on all walkways and stair landings. Provide notch in toe plate at post as required to maintain specified clearance.
7. Handrail system, which consists of three horizontal rail members, posts, connections and anchorages, shall be designed to withstand a 200-pound concentrated load applied at any point and in any direction or a 50 lb./ft. uniform load applied in any direction. Concentrated and uniform loads need not be assumed to act concurrently. The posts and associated floor flange anchorage shall be designed to withstand a 200-pound concentrated load applied at the top rail.
8. Provide expansion joint splices in all rails of handrail and toe board at not greater than 20 feet spacing and at expansion joints in concrete structure. Minimum projection of expansion splice inside adjacent pipe shall be 1½".
9. Splices and expansion joints in the railing system components shall be located within 8 inches of posts or other railing system supports.
10. Provide 1/4-inch weep holes at low points in all handrails and posts to prevent trapping of moisture.
11. Removable handrail to have vertical pipe supports fastened as shown on PLANS. Unless otherwise indicated, fabricate removable handrail in unit sections not exceeding 10 feet long with at least three vertical supports, including one at each end.
12. Handrails attached to load-bearing walls to be mounted with aluminum or stainless steel brackets. Fasten each bracket with a minimum 3/8-inch diameter Type 316 stainless steel expansion bolt set into the wall and tapped into bracket. Bracket to have a 3-inch projection from wall and be uniformly spaced approximately 4 feet with the end brackets not more than 12 inches from the ends of the handrails.
13. Posts and rails to be continuous throughout their sectional lengths. Curved members to be formed to true radii, free from dye marks or surface abrasions. Furnish handrail in shop fabricated sections, complete with accessories, including gates, hardware, closure caps for rail terminations, base trim, and anchorages.
14. Posts shall not interrupt the continuation of the top rail at any point along the railing, including corners and end terminations (OSHA 1910.23). The top surface of the top railing shall be smooth and shall not be interrupted by a projecting fitting.

15. Aluminum surfaces in contact with concrete, grout or dissimilar metals will be protected with a mylar isolator, bituminous paint or other approved material.
  16. Handrail system posts are to be anchored to concrete structures with Type 316 stainless steel bolts. Bolts and floor flange shall be designed to resist a 200-pound load applied horizontally to the top rail. Bolt manufacturer's published shear and pullout values shall be reduced for spacing and edge distance conditions as shown on plans.
  17. Safety Chains: Construct safety chains of stainless steel, straight link type, 3/16-inch diameter, with at least twelve links per foot, and with boat type snap hooks on each end. Provide S.S. 3/8-inch bolt with 3/4 -inch eye diameter for attachment of chain, anchored as indicated. Supply a minimum of two chains or as noted on PLANS, 4 inches longer than the anchorage spacing, for each guarded area. Locate safety chain where indicated.
- B. Nonwelded Aluminum Handrails
1. Fittings to be extruded or cast aluminum, 6063 Aluminum Alloy with a minimum 0.4-mil thick clear anodized finish per Aluminum Association Designation M43C22A4I.
  2. The handrail shall be made of pipes joined together with component fittings. Components that are glued or pop-riveted at the joints will not be acceptable. All components must be mechanically fastened with stainless steel hardware.
  3. Fitting shall be an internal double-prong expandable fitting that is activated by a stainless steel or aluminum set screw. The fitting shall be externally connected to the pipe by means of an anodized aluminum tubular rivet nut, and stainless steel socket head cap screw. All fittings, elbows, wall returns, and caps to be flush-type. Exposed fasteners to be set flush or recessed. All fasteners to be Type 316 stainless steel.
  4. Unless otherwise noted on PLANS, all handrails to be nonwelded aluminum.
- C. Welded Aluminum Handrail
1. Handrail and posts to be joined by welding only if indicated on PLANS. Welding to consist of flush-type weld fittings or coping of pipe ends to conform with adjoining pipe and welding. Welds to be ground smooth and flush.
  2. Elbows, capped terminations, and wall returns to be formed by flush fittings. Secure rails terminating against masonry or concrete with flanged fittings and anchor bolts.

## **2.03 FABRICATION**

Furnish railings in shop-fabricated sections, complete with accessories, including gates, plated hardware, closure caps for rail termination, base trim, and anchorages.

## **2.04 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 - 3.02 (NOT USED)**

## **3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION**

- A. Handrail to be installed by fabricator in strict compliance with fabricator's instructions. Install handrail plumb and within a tolerance of 1/4-inch maximum deviation either side of the longitudinal centerline. Cuts to be clean and straight, free from burrs and nicks.
- B. Posts embedded in concrete to be set in sleeves with quick-setting non-shrink grout.

- C. Install removable and permanent handrail units with bolted floor type flanges.
- D. Use of shims, washers, wedges, or similar devices are not allowed when plumbing or aligning handrail.

**3.04 - 3.10 (NOT USED)**

**3.11 MEASUREMENT AND PAYMENT**

No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**

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## SECTION 09902

### PAINTING AND PROTECTIVE COATINGS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Furnish and apply, as specified herein, paint and protective coatings to all surfaces, except steel water storage tanks, unless specifically excluded by this Section.

##### 1.02 RELATED REQUIREMENTS

- A. PLANS define special coating requirements.
- B. Related work as called for on PLANS, or in this or other TECHNICAL SPECIFICATION Sections.

##### 1.03 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.

#### STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC SP-1	Surface Preparation Specification No. 1 - Solvent Cleaning
SSPC SP-2	Surface Preparation Specification No. 2 - Hand Tool Cleaning
SSPC SP-3	Surface Preparation Specification No. 3 - Power Tool Cleaning
SSPC SP-5	Surface Preparation Specification No. 5 - White Metal Blast Cleaning
SSPC SP-6	Surface Preparation Specification No. 6 - Commercial Blast Cleaning
SSPC SP-7	Surface Preparation Specification No. 7 - Brush-Off Blast Cleaning
SSPC SP-8	Surface Preparation Specification No. 8 - Pickling
SSPC SP-10	Surface Preparation Specification No. 10 - Near-White Blast Cleaning

#### NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)

NACE No. 1	White Metal Blast Cleaning
NACE No. 2	Near-White Blast Cleaning
NACE No. 3	Commercial Blast Cleaning
NACE No. 4	Brush-Off Blast Cleaning

##### 1.04 DEFINITIONS (NOT USED)

##### 1.05 SYSTEM DESCRIPTION

- A. Surfaces receiving coatings include:
  - 1. Equipment, machinery, and metal surfaces.
  - 2. Interior surfaces, as noted in room finish schedule.
  - 3. Concrete surfaces, including concrete blocks (when noted on PLANS).
  - 4. Threads on field-threaded galvanized pipe and conduit.
  - 5. All cabinet and woodwork. (Stain finish unless otherwise noted.)
  - 6. Interior concrete surfaces of new lift station wet wells.

7. Paint concealed structural steel and steel joists, after erection of deck and before steel is enclosed.
  8. Procedures and coating systems specified herein are in addition to shop priming and surface treatment specified in other TECHNICAL SPECIFICATION Sections.
- B. Unless otherwise noted or shown, the following areas or items do not require coating:
1. Non-ferrous and corrosion-resistant ferrous alloys such as copper, bronze, monel, aluminum, stainless steel, chromium plate, and atmospherically exposed weathering steel, except where:
    - a. Required for electrical insulation between dissimilar metals;
    - b. Aluminum and stainless steel are embedded in concrete or masonry, or aluminum is in contact with concrete or masonry;
    - c. Color coding of equipment and piping is required.
  2. Non-metallic materials such as glass, PVC, porcelain, and fiberglass, except as required for architectural painting or color coding.
  3. Pre-finished electrical and architectural items such as motor control centers, switchboards, switchgear, panelboards, transformers, disconnect switches, panelboards, acoustical tile, cabinets, elevators, building louvers, etc., except when color coding of equipment is required.
  4. Non-submerged electrical conduits attached to unpainted concrete surfaces.
  5. Items specified to be galvanized after fabrication unless specified elsewhere or subject to immersion.
  6. Insulated piping except as required for architectural painting or color coding.

#### **1.06 SUBMITTALS**

Submit the following in accordance with Specification Section 01300, "Submittals".

- A. Painting Schedule: Submit list indicating major items to be painted, preparation, paint manufacturer, product designation, and dry mil thickness.
- B. Panels
  1. Submit panels containing samples of proposed paints and coatings. Include three displays of each kind and color of paint used. Panel to be representative of material to be coated.
  2. Mark panels to indicate respective types of surfaces to which several kinds and colors of paint, stain, and coating are applied.
- C. Samples: If requested by OWNER, submit 1/4 pint of each kind of paint or stain proposed for use. Do not deliver materials to site until representative samples (if requested) have been approved.
- D. For all materials, furnish ENGINEER with two sets of manufacturer's printed instructions describing surface preparation procedures and application procedures including environmental limits (temperature and humidity).
- E. List of five similar projects in accordance with Paragraph 1.07 B.1.
- F. Material Safety Data Sheets (MSDS) for all coatings, solvents, sealers, and paints to be utilized.

#### **1.07 QUALITY ASSURANCE**

- A. Manufacturer: All paints, sealers, and coatings to be manufactured by those firms listed in Table 2. Products of equal quality by other manufacturers will be considered, subject to review of written submittal that includes product data and a detailed paint and coating schedule.
- B. Workmanship



1. Furnish workers who perform quality work and who are experienced and knowledgeable in the surface preparation and application of high-performance industrial coatings. Submit list of five similar projects which have been prepared and coated by the personnel which the CONTRACTOR proposes to employ for this project.
  2. Submit manufacturer's written instructions on cleaning and coating prior to any surface preparation or coating.
- C. Whenever possible, all coatings should be from single manufacturer. Unless otherwise specified, coating materials for a specific surface or piece of equipment are to be from a single manufacturer.
- D. All coatings provided for use on this project in the field or from equipment suppliers will be in compliance with Federal, State, and local laws, regulations and ordinances related to items such as lead, chromate, carcinogens and volatile organic compounds. For potable water systems, all coatings and products used on surfaces 1) in contact with the water, 2) within 1 foot above the high water level and below the high water level, or 3) in contact with materials to be introduced into the water, to be National Sanitation Foundation (NSF) approved for potable water service.

#### **1.08 DELIVERY, STORAGE AND HANDLING**

- A. Deliver to site in original, sealed containers with manufacturer's label attached.
- B. Store in a protected area that is heated or cooled to maintain temperature range recommended by manufacturer. Protect all materials from weathering and extreme temperatures.
- C. Waste and any hazardous material remaining at the end of the day to be discarded in accordance with national, state, and local regulations.

#### **1.09 - 1.11 (NOT USED)**

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Coating manufacturers are listed by generic type and service in Table 2 attached to this Section.

#### **2.02 MATERIALS**

- A. Tables 1 and 2 in this Section include the paint, protective coatings, and sealers for this project. Furnish all such special materials required for the manufacturer's coating systems whether or not included in the Tables.
- B. Products to comply with Federal, State, and local requirements limiting the emission of volatile organic compounds. The maximum volatile organic content of the combination of coating and thinner is not to exceed the following limits (whichever is less):
1. 3.5 pounds per gallon; or
  2. The Federal, State or local limit.
- C. Colors
1. OWNER reserves the right to select colors.
  2. Submit list of items to be painted and color charts for each type of surface.
  3. Formulate with colorants free of lead or lead compounds.
  4. Proprietary color identification is for selection purposes only. Any authorized manufacturer may supply matches.

- D. Safety Color Codes: Follow OSHA requirements of 29 CFR, Part 1910.144 for "Safety Color Codes for Marking Physical Hazards". The following general requirements are set forth as a guide.
1. Red: Fire protection equipment, danger signs, and fire exit signs. Portable containers of flammable material to be red with yellow band or name of contents stenciled in yellow.
  2. Orange: Moving or rotating parts of equipment protected by guards, including shafts and couplings, pulleys, and sprockets. (Do not paint wearing surfaces.)
  3. Yellow: Caution signs and all physical hazards, including outside levers and weights on check valves, lower pulley blocks and hooks, sprockets and chains on valve operators, inside of openings adjacent to step or ladders, platforms provided for vertical ladders at transition levels, exposed unguarded edges of pits, platforms and walls subject to being struck, and any piping or equipment extending into normal operating areas.
  4. Green: To designate "Safety" and location of first-aid equipment such as gas masks, first-aid kits, and safety deluge showers.
  5. Black and White: To indicate areas that must remain clear, such as areas around first-aid, fire-fighting, and other emergency equipment.

- E. Piping Color Coding: The identification of process piping and chemical feed lines is to be accomplished by various colors of paint. Color coding to be by solid color and labels. Provide pipe color coding in accordance with applicable Specification Section.

1. Wastewater Plant Color Codes:

<u>LETTERING</u>	<u>COLOR OF PIPE</u>
Sludge	Brown
Natural gas	Red
Potable water	Light Blue
Chlorine	Yellow
Sulfur dioxide	Lime green with yellow bands
Sewage	Grey
Compressed air	Light Green
Heated water	Blue with 6 inch red bands spaced 30 inches apart
Power conduit	In compliance with the National Fire Protection Association 70 National Electrical Code®
Reclaimed water	Purple with black lettering
Gray water	Purple with yellow writing
Instrument air	Light green with dark green bands;
Liquid alum	Yellow with orange bands
Alum (solution)	Yellow with green bands
Ferric chloride	Brown with red bands
Ferric sulfate	Brown with yellow bands
Polymers	White with green bands
Ozone	Stainless steel with white bands
Raw water	Tan
Effluent after clarification	Dark green

2. Piping containing gas, chlorine or other hazardous materials are to be color coded when exposed, located out of view, or buried.
3. Non-potable water lines are to be painted white and marked with black lettering at maximum 5-foot intervals.

## 2.03 - 2.04 (NOT USED)

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. Use one convenient location for storing and mixing of materials and keep fire extinguisher available in this area as long as location is used for such purpose.
- B. Thinners and Solvents: Use only those thinners and solvents specified in paint formulas of paint being used and mix in proportions recommended by paint manufacturer.
- C. Coverage: As recommended by paint manufacturer and sufficient to obtain minimum mil thickness specified. Do not exceed maximum thickness specified by manufacturer, if applicable. After final coat is applied, check with elecometer or Mikrotest dry film thickness gauge.
- D. Drying Time: Between successive coats, allow drying time as specified by paint manufacturer. Do not apply additional coats until previous coat is completed.
- E. Provide adequate ventilation for proper curing. Keep materials sealed when not in use.
- F. Environmental conditions such as temperature and humidity to be within the ranges recommended by the coating manufacturer.
- G. Finish coats to be smooth, free of brush marks, streaks, laps or pile up of paints, and skipped or missed areas. Finished metal surfaces to be free of voids or pinholes in any coat when tested with a low voltage detector.

### **3.02 PREPARATION**

- A. General
  - 1. Perform all preparation and cleaning procedures in strict accordance with paint manufacturer's instructions and as specified for each substrate.
- B. Concrete Surfaces
  - 1. Prior to painting, surfaces to be free of all latent matter, burrs, and fins, using one or more of the following methods.
    - a. Remove oil and grease with detergent and thoroughly rinse with fresh water.
    - b. Abrasive blasting may be used only if machinery or other equipment in vicinity of work is adequately protected. Also, avoid settling of dust or grit on freshly painted surfaces.
    - c. Wash concrete surfaces with 10 percent solution of muriatic acid, then wash clean and free of scale, mortar, dust, moisture, and other foreign matter.
    - d. Repair all honeycomb surface defects by coating cleaned honeycombed area with epoxy bonding agent and filling voids with non-shrink grout leaving a smooth uniform concrete surface.
  - 2. If curing compound is used, it must be removed prior to coating.
- C. Metal Surfaces
  - 1. Clean metal surfaces by abrasive blasting in shop as required by Table I and leave clean, dry, and ready to receive prime coat. Provide moisture separators to effectively remove all oil and free moisture from air supply. Cleanliness of air to be tested by impinging an abrasive-free air stream onto a white cloth for one minute. If oil or moisture is detected, air source to be shut down and corrected.
  - 2. Remove all dust and abrasives from surfaces by brushing or blowing with clean, dry air. Remove abrasive grit around and between joints of connecting members.

3. Perform field abrasive blasting only if required to correct unsatisfactorily cleaned and shop-primed metal and when approved by ENGINEER.
  4. Removal of Oil and Grease: Remove oil and grease with a solvent approved by coating manufacturer, or by steam combined with detergent (in accordance with SSPC SP-1). Use of gasoline, kerosene, naphtha, or carbon tetrachloride not permitted.
  5. Brushing, Scraping, Grinding, and Chipping: In field work, if abrasive blasting is not possible, scrapers, wire brushes, and other suitable grinding or chipping tools may be used (in accordance with SSPC SP-2 or SP-3) for removal of existing paint coatings prior to repainting, or for cleaning, before applying second coats.
  6. Surface to be coated on same day as cleaned and before rust bloom occurs. Surfaces which have been cleaned but which have started to show signs of rust or dirt are to be cleaned again prior to coating at no additional expense to OWNER.
  7. All surfaces to be at least 5°F or higher above the dew point and remain this way when blasting, priming, or coating.
- D. Galvanized Surfaces
1. Clean surface with mineral spirits to remove oil residue.
  2. Dry with a clean cloth.
- E. Wood Surfaces
1. Clean soiled surfaces in accordance with coating manufacturer's instructions.
  2. Sand to a smooth even surface and then dust off.
  3. Apply shellac to all knots, pitch and resinous sapwood before priming coat is applied.
  4. Fill nail holes, cracks, open joints and other defects with putty after priming coat has dried. Tint putty to match finish color. Sand smooth after putty dries.
  5. Apply priming coats to woodwork as soon as practical after woodwork is delivered.
  6. Top and bottom edges of all wood doors to be primed and sealed after fitting and before final hanging.
- F. Gypsum Wallboard
1. Fill narrow, shallow cracks and small holes with spackling compound.
  2. Rake deep, wide cracks and deep holes.
    - a. Dampen with clean water.
    - b. Fill with thin layers of drywall joint compound
  3. Allow repairs to dry.
  4. Sand smooth. Do not raise nap of paper on wallboard.
- G. Plastic Surfaces:
1. Hand sand plastic surfaces to be coated with a medium grit sandpaper to provide tooth for coating system.
  2. For surfaces with existing coatings, completely remove any existing coating and prepare surface as mentioned above.

### **3.03 ERECTION, INSTALLATION AND APPLICATION INSTRUCTIONS**

- A. General
1. Do not apply initial coating until moisture content of surface is within limitations recommended by paint manufacturer. Test with moisture meter.
  2. Slightly vary the color of successive coats.
  3. Sand and dust between each coat to remove defects visible from a distance of 5 feet.

4. Make edges of paint adjoining other materials or colors clean and sharp with no overlapping.
  5. Change colors at corner of stop where colors differ between adjoining spaces or rooms and where door frames match wall colors.
  6. Do not proceed with field applied painting of shop-coated items until any defective work has been cleaned by sandblasting.
- B. Brush Application
1. Brushes: Use first-quality hog hair or suitable synthetic bristle brushes. Use of horsehair bristle brushes not permitted. Keep brushes clean and free from accumulation of dried paint or dirt, and when brushes for oil or varnish base paints are not in use, keep them suspended in raw linseed oil bath. Clean brushes with proper solvent before reuse.
  2. Application: Apply in uniform thickness consistent with specified coverage and with sufficient cross-brushing to ensure filling of surface irregularities. Exercise particular care in painting around bolt heads and nuts and in corners and other restricted spaces.
- C. Conventional Spray Application: Apply with adjustable air gun equipped with suitable water trap to remove moisture from compressed air, and with paint pot having air driven or mechanical agitator. Adjust width of spray to meet the requirements of the surface being coated with suitable air pressure for the particular type of paint being used. Make frequent checks to ensure correct spreading rate and coating and apply without sags, runs, or "orange peel" effect. Correct all such imperfections. Take special care to cover edges, corners, and bolt heads, without bridging over of paint film.
- D. Airless Spray Application: Equipment used for airless spray to be designed for, and capable of handling, the volume and pressures necessary to ensure smooth and proper application. Hoses to be specifically designed for the viscosity of the material being sprayed and be of the non-static, self-grounding type. Tips to be properly sized to ensure complete atomization and the spray pattern is to be continuous and free of all fingering effects.
- E. Roller Application: Proper length nap rollers to be used to ensure a smooth application free of runs, sags, roller marks, or air bubbles. Use longer nap for rougher surfaces when specified on PLANS. Phenolic core lambs wool type rollers to be used when polyurethanes, epoxies, or other types activated coatings are applied by roller. Standard type rollers to be used on water based and enamel coatings. Rollers to be of sufficient quality to leave finished surfaces free of lint, roller nap, runs, sags, and other imperfections. Roller is not to exceed 24 inches in length.
- F. Metal Surfaces
1. Shop-prime metal surfaces, if required, prior to delivery to job site.
  2. After delivery and prior to installation, keep all coated metal surfaces clean and free from corrosion. Clean and touch up or repaint damaged areas with additional primer.
  3. After erection or installation of metal work, clean and touch up all rust spots, all places where primer has been rubbed or scraped off, and all bolts and nuts. After previously applied paint has hardened, and when surfaces to receive succeeding coats of paint have been cleaned and dried, apply finish paint in accordance with Tables 1 and 2. Allow 7 days or more, as recommended by coating manufacturer, for curing of final coat for submerged surfaces.
  4. Factory-Finished Equipment: After installation of factory-finished machinery and electrical equipment, check base coats carefully and touch up all damaged surface areas. Do not paint nameplates, serial number bases, chrome, or bronze trim. Clean off any excess paint that impairs convenient removal of covers on gauges, instrumentation, or other equipment fitted with doors or covers.

5. Factory-Primed Equipment: Delay final field coating to manufacturer's primed equipment until equipment has been installed and is in proper working order in accordance with the applicable Section.
- G. Mixing and Tinting
1. Deliver paints and enamels ready mixed to job site.
  2. Accomplish job mixing and job tinting only when acceptable to the ENGINEER.
  3. Mix only in mixing pails placed in suitably sized non-ferrous or oxide resistant metal pails.
  4. Use tinting colors recommended by manufacturer for the specific type of finish.
  5. Multiple-Component Coatings:
    - a. Prepare using all the contents of the container for each component as packaged by the manufacturer.
    - b. No partial batches permitted.
    - c. Do not use multiple component coatings that have been mixed beyond their pot life.
    - d. Provide small quantity kits for touch up painting and for painting small areas.
    - e. Mix only components specified and furnished by coating manufacturer.
    - f. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.
- H. Special Requirements: Cast iron or ductile iron piping and valves for interior and exterior aboveground installation with a factory-applied bitumastic or asphaltum varnish coating to be cleaned by abrasive blasting to a NACE No. 3 finish for interior installations and a NACE No. 2 finish for exterior surfaces. Primer and finish coat to be applied in accordance with Table 1. If primer is not applied within 24 hours, surfaces to be retreated.

### **3.04 REPAIR/RESTORATION**

- A. Leave all parts of moldings and ornaments clean and true to details with no undue amount of paint in corners and depressions.
- B. Remove all masking products used to protect hardware or built-in work.
- C. Final Cleaning and Touch Up
1. Touch up and restore finish where damaged.
  2. Do not mar surface finish of item being cleaned.
- D. Refinish whole wall where portion of finish has been damaged or is not acceptable.
- E. Damaged Coatings, Pinholes and Holidays
1. Feather edges and repair in accordance with recommendations of coating manufacturer.
  2. Repair fusion bonded coatings as recommended by original applicator. Applicator to furnish liquid repair kits for this purpose as recommended by the coating manufacturer.
  3. Apply finish coats, including touch up and damage-repair coats, in a manner which presents a uniform texture and color-matched appearance.
- F. Unsatisfactory Application
1. If coating has improper finish color or insufficient film thickness: Clean and top coat surface with specified material to obtain specified color and coverage. Obtain and follow specific surface preparation information for top coating from coating manufacturer.

2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat in accordance with this Section. Depending on extent of repair and appearance, a finish sanding and top coat may be required.
3. Evidence of runs, sags, bridges, shiners, laps, or other imperfections to be cause for rejection.
4. Repair defects in coating system per written recommendations of coating manufacturer.
5. Leave all staging in place until ENGINEER has inspected surface or coating. Replace staging removed prior to inspection and approval by ENGINEER.

### **3.05 FIELD QUALITY CONTROL**

- A. Schedule field operations to avoid settling of dust or grit on freshly painted surfaces, and adequately protect machinery or other equipment in vicinity of abrasive blasting work.
- B. Request review by OWNER of first finished room, space, or item, of each color scheme for color, texture, and workmanship.
- C. Use first acceptable room, space or item (as determined by OWNER), as project standard for each color scheme.
- D. For spray application, paint an area no smaller than 100 square feet as the project standard.

### **3.06 ADJUSTING (NOT USED)**

### **3.07 CLEANING**

- A. During the progress of the work, remove from the project site at the close of each day's work, all oily rags, discarded materials, rubbish, cans, and dispose of in accordance with national, state, and local regulations.
- B. On completion of operations, remove all spots, oil, and stain from all surfaces and leave entire project in clean condition as far as this work is concerned.
- C. Remove from premises all containers and debris resulting from this work and dispose of in accordance with Federal, State and local regulations.
- D. Upon completion of the work remove staging and scaffolding from the site.

### **3.08 TESTING AND INSPECTION**

- A. CONTRACTOR is to perform routine quality control testing on each coat to ensure the integrity of the protective coating. At a minimum, the following tests are to be performed.
  1. Dry film thickness.
  2. Holiday testing.
  3. Any additional tests as recommended by coating manufacturer.
- B. Any and all testing performed by the ENGINEER is for the sole purpose of verifying compliance with this specification. CONTRACTOR is not to rely upon testing performed by the ENGINEER as a means of quality control.
- C. CONTRACTOR to provide the following equipment for use by the ENGINEER.
  1. One magnetic pull-off type, non-destructive paint film thickness gauge, such as a Mikrotest thickness gauge. Thickness gauge to become OWNER's.

2. One set of certified coating thickness calibration standards produced by the U.S. Department of Commerce. Calibration standards to become OWNER's.
  3. One "wet sponge", low voltage, D.C. type holiday detector, such as the Tinker-Rasor Electrical Holiday Detector.
- D. Provide the ENGINEER with the proper safety equipment for observation and testing of the applied coating.
- E. To facilitate ENGINEER's inspection of coated surfaces, CONTRACTOR to provide scaffolding/rigging and adequate illumination as required to perform the dry film thickness reading and holiday test inspections as required by this specification and the referenced standards. Provide personnel to move the scaffolding, lighting, or rigging at the request of the ENGINEER.
- F. No equipment is to be placed in service until the protective coating has been tested and approved by the ENGINEER.

### **3.09 PROTECTION**

- A. CONTRACTOR is solely and completely responsible for conditions of the job site including safety of all persons (including employees) and property during performance of the work. This requirement applies continuously and is not limited to normal working hours. Conform with safety provisions of the U.S. Department of Labor, Occupational Safety and Health Act, any equivalent State law, and all other applicable Federal, State, and local laws, ordinances, and codes.
- B. Protect floors and all other areas where work is done, with suitable drop cloths.
- C. Remove, mask, or otherwise protect all hardware, hardware accessories, lighting fixtures, switchplates, machined surfaces, couplings, shafts, bearings, labels, nameplates, etc. and other surfaces not intended to be painted prior to surface preparation and painting. Reinstall the removed items by workmen skilled in the trades involved.
- D. CONTRACTOR is cautioned of the potential risk of damage and/or nuisance to the adjoining property and/or structures. CONTRACTOR is responsible for providing necessary equipment and/or controls to minimize the carryover of dust, paint, and abrasives. If excessive dust, paint, or abrasives are determined by the OWNER, or their representative, to be affecting adjoining property and/or structures, CONTRACTOR to utilize shrouds, drop tubes, or other means to confine a minimum of 95 percent of the abrasive, paint, and other material to the associated work area.
- E. Protect working parts of mechanical and electrical equipment from damage. Mask openings in motors to prevent paint and other materials from entering motor.

### **3.10 SCHEDULES**

- A. Attachments to this Section define System Schedule (Table 1) and Coating Schedule (Table 2).

### **3.11 MEASUREMENT AND PAYMENT**

No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.



**TABLE 1 – SYSTEM SCHEDULE**

Type of Surface	Exposure	Surface Preparation/ Cleaning	Table 2 – Material Reference				Minimum Total Mils Thickness
			Primer	1 <sup>st</sup> Coat	2 <sup>nd</sup> Coat	3 <sup>rd</sup> Coat	
Clay or Brick Masonry	Exterior <sup>(1)</sup>	Manufacturer's Specification	—	1	—	—	NA
Concrete Block Buildings	Exterior	Manufacturer's Specification	—	2	4	4	3.0 (Finish Coat)
Concrete Block Walls	Interior <sup>(2)</sup> Painted	- Paragraph 3.02 B	—	3	4	4	3.0 (Finish Coat)
	Interior <sup>(2)</sup> Sealed	- Paragraph 3.02 B	—	3A	—	—	NA
Concrete Walls and Ceilings	Interior	Paragraph 3.02 B	—	3	4	4	3.0 (Finish Coat)
Wood	Exterior Interior	and Manufacturer's Specification	10	11	11	—	4.5
Wood, Clear Finish, Satin	Interior	Manufacturer's Specification	23, 24	25	26	26	4.0
Wood, Clear Finish, Gloss	Interior	Manufacturer's Specification	23, 24	25	27	27	4.0
Wallboard (Semi-Gloss)	Interior	Manufacturer's Specification	19	20	22	22	4.0 + texture
Wallboard (Flat)	Interior	Manufacturer's Specification	19	20	21	21	4.0 + texture
Metal Doors, Frames and Windows	Exterior Interior	and NACE-#4 1.0 Mils Surface Profile	18	9	—	—	4.0
Structural and Misc. Steel	Exterior	NACE-#2 1.0-2.0 Mils Surface Profile	16	18	9	—	7.0
Structural and Misc. Steel	Interior	NACE-#3 1.0-2.0 Mils Surface Profile	16	17	—	—	5.5
Piping and Valves	Interior <sup>(2)</sup>	NACE-#3	6	17	—	—	4.5
	Exterior <sup>(1)</sup>	NACE-#2 1.0-2.0 Mils Surface Profile	6	18	9	—	6.0
Valves and Bolting on C.I. Buried Pipe		—	—	14	14	—	32.0

**TABLE 1 – SYSTEM SCHEDULE**

Type of Surface	Exposure	Surface Preparation/ Cleaning	Table 2 – Material Reference				Minimum Total Mills Thickness
			Primer	1 <sup>st</sup> Coat	2 <sup>nd</sup> Coat	3 <sup>rd</sup> Coat	
Factory Finished Machinery, Electrical, and Motors <sup>(3)</sup>	Interior and Exterior	Hand Clean	5 <sup>(4)</sup>	8 <sup>(5)</sup>	8 <sup>(5)</sup>	—	4.5
Galvanized Steel	Interior	Solvent Cleaning	15	17	—	—	2.9
Galvanized Steel and Galvanized Pipe Conduit Threads	Exterior	Solvent Cleaning	15	18	9	—	4.4
Wastewater Treatment Plant Equipment, Piping	Submerged <sup>(6)</sup>	NACE-#2 2.0-3.0 Mills Surface Profile	28	29	—	—	45.0
Wastewater Wet-Well	Interior Surfaces	Paragraph 3.02 B	6	13	13	—	22.0
Special Surfaces Noted on PLANS	Surfaces as Shown on PLANS	Hydroblast and SSPC SP-7 <sup>(8)</sup>	28	29	—	—	125.0

**NOTES:**

- (1) Surface or piping above ground exposed to weathering.
- (2) Surface or piping above ground sheltered from weathering.
- (3) Use coating system per equipment Section when specified.
- (4) Optional: Use manufacturer's standard primer if compatible with specified finish coats.
- (5) Optional: Use manufacturer's standard finish coat.
- (6) Piping or equipment that is submerged or partially submerged in a fluid.
- (7) Coatings used must be in the latest publication of National Sanitation Foundation (NSF) ANSI/NSF Standard 61.
- (8) Shop priming on iron/steel materials is not required. Surface preparation and primer are done in field. Concrete surface preparation involves 1/4" wide × 1/4" deep saw cut to anchor coating to surface.

**TABLE 2 – COATING SCHEDULE**

<b>Symbol</b>	<b>Min. Dry Mils Per Coat*</b>	<b>Service</b>	<b>Generic Type</b>	<b>Brand and Manufacturer</b>
1.	NA	Primary Sealer	Chemical Penetrant	Aqua-Gard - CreteGard Corp. Seal Krete - ICI Devoe #89424
2.	NA	Weather-proof Primary Sealer	Acrylic Emulsion	ACRO 2290 DTM Acrylic Latex - ACRO Amercoat 148 - Ameron Tru-Glaze 4010 - ICI Devoe
3.	NA	Primary Sealer	Vinyl-Acrylic Emulsion with Epoxy Esters	ACRO 1153 Latex Block Filler - ACRO Amercoat 148 - Ameron Blaxfil 4000 - ICI Devoe
3A.	NA	CMU, Clear Block Sealer	Siloxane Sealer, 10% Siloxane-Acrylic Emulsion	OKON W-2 Saver Systems WB Aqua-Trete EM - Sivent
4.	1.5	Finish Coat	Acrylic Emulsion	ACRO 2288 Exterior Latex - ACRO Amercoat 220 - Ameron LifeMaster-Pro 4226 - ICI Devoe
5.	1.5	Metal Primer	Alkyd	ACRO 1104 Heavy Duty Primer - ACRO Amercoat 5105 - Ameron Carbocoat 150 - Carboline Devguard 4160 - ICI Devoe
6.	2.0	Metal Primer or Concrete Surfaces	Polyamide Epoxy Resin	Cured ACRO 4422 Epoxy Primer - ACRO Amercoat 385PA - Ameron Carboguard 888 - Carboline 13-R-62-Epoxy Primer - Valspar BarRust 231 - ICI Devoe
7.**	2.0-4.0 (as recommended)	Metal Primer	Polyamide Epoxy Resin	Cured ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 385PA - Ameron Carboguard 561 - Carboline Valspar 90HS - Valspar BarRust 233H - ICI Devoe
8.	1.5	Finish Coats	Alkyd, Straight Long-Oil	ACRO 2214 Heavy Duty Enamel - ACRO Amercoat 5450 - Ameron Carbocoat 139 - Carboline Devguard 4308 - ICI Devoe
9.	2.0	Finish Coat	Aliphatic Urethane	ACRO 4429 Polyurethane - ACRO Amercoat 450HS - Ameron Carbothane 134HG - Carboline V40 Polyurethane Enamel - Valspar Devthane 389 - ICI Devoe
10.	1.5	Wood Primer	Oil Base	ACRO 2214 Enamel (Thinned 10%) - ACRO Amercoat 5105 - Ameron Carbocoat 139 - Carboline Ultrahide 2110 - ICI Devoe

**TABLE 2 – COATING SCHEDULE**

<b>Symbol</b>	<b>Min. Dry Mils Per Coat*</b>	<b>Service</b>	<b>Generic Type</b>	<b>Brand and Manufacturer</b>
11.	1.5	Finish Coat	Alkyd, Straight Long-Oil	ACRO 2214 Heavy Duty Enamel - ACRO Amercoat 5405 - Ameron Carbocoat 139 - Carboline Devguard 4308 - ICI Devoe
12.**	4.0-6.0 (as recommended)	Submerged Steel, Iron, or Concrete Surface	Polyamide-Cured Epoxy Resin	ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 370 - Ameron Carboguard 561 - Carboline BarRust 231 - ICI Devoe
13.	10	Submerged Steel, Iron, or Concrete Surface	Coal-Tar Epoxy Two Component	ACRO 4467 Coal Tar Epoxy - ACRO Amercoat 78HB - Ameron Bitumastic 300M - Carboline
14.	16	Buried Steel or Iron	Tar-Base Pitch	ACRO 8500 Heavy Duty Coal Tar - ACRO Bitumastic No. 50 - Kop-Coat Devtar 247 - ICI Devoe
15.	0.4	Galvanized Metal Primer	Vinyl Wash Primer	ACRO 1162 Vinyl Wash Primer - ACRO Galva-Prep - Ameron Rustbond Penetrating Sealer - Carboline Devran 205 - ICI Devoe
16.	3.0	Steel Above Ground & Above Waterline	High Ratio Inorganic Zinc Silicate	ACRO 5502 Inorganic Zinc - ACRO Dimetcote 9 - Ameron V13-F-12 Inorganic Zinc - Valspar Catha-Coat 302H - ICI Devoe
17.	2.5	Steel Interior	Polyamide Epoxy Resin Cured	ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 385 - Ameron Carboguard 561 - Carboline Bar-Rust 231, Devran 224HS - ICI Devoe
18.	2.0	Intermediate Finish		ACRO 4460 Chemical Resistant Epoxy - ACRO Amercoat 385 - Ameron Carboguard 561 - Carboline Devran 220 - ICI Devoe
19.	NA	Texture	Emulsion	Ready-Mixed Texture Compound - U.S.Gypsum Speedhide Texture Emulsion - PPG
20.	1.2	Sealer	Vinyl-Latex	Quick-Drying Latex Sealer, 6-2 - PPG Interior Vinyl Latex Primer-Sealer, 50801 - Devoe
21.	1.4	Finish Coat-Flat	Synthetic Alkyd Resin	Alkyd Flat Wall Enamel - Negley Speedhide Alkyd Flat, 6 Line - PPG 50801 - Devoe
22.	1.4	Finish Coat Semi-	Synthetic Alkyd Resin	Coronado Supercoat 5000

**TABLE 2 – COATING SCHEDULE**

<b>Symbol</b>	<b>Min. Dry Mils Per Coat*</b>	<b>Service</b>	<b>Generic Type</b>	<b>Brand and Manufacturer</b>
		Gloss		Speedhide Alkyd Lo-Sheen Enamel, 6 Line - PPG Velour Interior Alkyd Semi-Gloss Enamel - 26XX Devoe
23.	NA	Wood Filler	Alkyd Resin w/Linseed Oil	Paste Wood Filler - Negley Natural Paste Wood Filler - PPG Interior Solvent Base Paste Wood Filler 4800 - Devoe
24.	NA	Stain	Synthetic Alkyd Resin	Coronado Quick Seal Rez Interior Wiping Stain, Alkyd Oil Type, Quick Drying, 77-302 - PPG Penchrome DF203 - ICI Devoe
25.	1.0	Sealer/Primer	Synthetic Alkyd Resin	Rez Sealer-Primer, 77-1 - PPG
26.	1.5	Clear Finish, Satin	Polyurethane Varnish	Coronado Polyurethane 67 Series Rez Polyurethane Satin Clear Plastic Varnish, 77-89 - PPG DF500 - ICI Devoe
27.	1.5	Clear Finish, Gloss	Polyurethane Varnish	Coronado Polyurethane 67-10 Rez Exterior/Interior Polyurethane Gloss Clear Plastic Varnish, 77-55 - PPG
28.	5	Steel, Iron or Concrete Surface	Modified Amine-Addnet Epoxy	Polybrid 670S - Polybrid Coatings, Inc. (no "or equal")
29.	40-120	Steel, Iron or Concrete Surface	Elastomeric Polyurethane Aromatic	Polybrid 705 - Polybrid Coatings, Inc. (no "or equal")

\*Or manufacturer's standard, whichever is greater. Do not exceed manufacturer's maximum standard, if applicable.

\*\*For potable water use.

**END OF SECTION**

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## **SECTION 11321**

### **CATENARY CLEANING MECHANISM FOR BAR RACK SCREENS**

#### **PART 1 - GENERAL**

##### **1.01 DESCRIPTION:**

- A. Provide, install and test mechanically cleaned catenary mechanisms gear reducers, motors, controls and appurtenances for installation on existing bar rack screens, as indicated and specified. Prior to start of fabrication, Contractor shall field verify all dimensions of existing bar rack screens to confirm fabrication requirements.

##### **1.02 REFERENCES:**

- A. American Society for Testing and Materials International (ASTM):
  - 1. A48: Specification for Gray Iron Castings.
- B. National Electrical Manufacturers Association (NEMA):
  - 1. MG1: Motors and Generators.

##### **1.03 SUBMITTALS:**

- A. Submit the following shop drawings in accordance with Section 01300:
  - 1. Certified shop and erection drawings. Contractor shall submit electronic files of the proposed equipment in the capacity, size, and arrangement as indicated and specified.
  - 2. Drawings showing materials of construction, thicknesses, operating and maintenance envelope and assembly weight.
  - 3. Strength calculation verifying compliance to the specified criteria.
  - 4. Shop drawing data for accessory items.
  - 5. Certified setting plans, with tolerances, for anchor bolts.
  - 6. Shop drawings showing the field confirmed spacing between the bars on the existing bar screens and proposed tooth pattern to be provided for the rakes.
  - 7. Manufacturer's literature as needed to supplement certified data.
  - 8. Operating and maintenance instructions and parts lists.
  - 9. Bearing temperature operating range for the service conditions specified.
  - 10. List of recommended spare parts other than those specified.
  - 11. Shop and field inspection reports.

12. Bearing Life: Certified by the equipment manufacturer. Include design data.
13. Equipment shop test results.
14. Qualifications of field service engineer.
15. Recommendations for short and long-term storage.
16. Shop and field testing procedures, set up and equipment to be used.
17. Special tools.
18. Gear reducer data including service factor, efficiency, torque rating and materials
19. Schematic control and power wiring diagrams including interconnecting and internal wiring diagrams
20. Control panel drawings
21. Manufacturer's product data, specifications and color charts for shop painting.
22. Provide listing of reference installations with contact names and telephone numbers.
23. Equipment weight and lifting points for installation and removal purposes.
24. Number, size and weight of pieces shipped.
25. Material Certification:
  - a. Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of five (5) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
  - b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.

#### **1.04 SPARE PARTS:**

- A. Provide spare parts that are identical to and interchangeable with similar parts installed.
  1. Furnish following spare parts for mechanically cleaned screens:
    - a. One set of sprockets.
    - b. Two cross members with rake teeth.
    - c. Two complete running strands of screen chain for each side of the screen assembled with attachment fittings and coupling and cotter pins, and four additional loose attachment fittings.



- d. One complete drive chain.
  - e. One complete set of bearings for each size screen.
  - f. 50 shear pins.
2. One set of all special tools required.

**1.05 QUALITY ASSURANCE:**

- A. Submit the following in accordance with Specification Sections 01300 "Submittals" and Specification Section 01730 "Operation and Maintenance Data".
- B. Equipment specified shall be the product of one manufacturer.
- C. The Contractor shall obtain the catenary cleaning mechanism, gear reducers, motors and appurtenances from a single manufacturer, as a complete and integrated package to ensure proper coordination and compatibility and operation of the system.
- D. Equipment specified shall be manufacturer's standard cataloged product and modified to provide compliance with the drawings, specifications and the service conditions specified and indicated.
- E. Welding: In accordance with latest applicable American Welding Society Code or equivalent.
- F. Shop tests as specified.
- G. Services of Manufacturer's Representative as stated in Section 01400 and as specified herein.
- H. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
  - 1. Service Technician must have a minimum of five (5) years of experience, all within the last seven (7) years, on the type and size of equipment.
  - 2. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Provide a minimum of 4 person-days.
  - 3. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of electrical and miscellaneous utility connection:
  - 4. Functional Testing: Calibrate, check alignment and perform a functional test. Tests to include all items specified.
  - 5. Field Performance Testing: Field performance test equipment specified.
  - 6. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.

7. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.
- I. Manufacturer of specified equipment shall have a minimum of five (5) operating installations with equipment of the size specified and in the same service as specified operating for not less than ten (10) years.
- J. If equipment proposed is heavier or taller, different width, or different discharge arrangement than specified and indicated; provide all structural, architectural, mechanical, electrical and plumbing revisions at no additional cost to the Owner.
- K. Electrical Equipment Labeling Requirements:
  1. Provide equipment labeled by a nationally recognized testing company where standards have been established. Where equipment is not available with label, provide service of a nationally testing company to examine the equipment and certify in writing that it complies with its safety standards. Tests and inspections of equipment shall be at no additional cost to Owner.
- L. Provide all components made of stainless steel pickled and passivated by full submergence in a pickling bath for required surface finishing. No stainless steel components may be fabricated or assembled in a factory where carbon steel products are also fabricated, in order to prevent contamination by rust.
  1. Fully submerge all stainless steel parts in a pickling bath for at least 8 hours to remove welding spots and to protect the stainless steel against corrosion. Sand or glass bead blasted or brushed or otherwise not equivalently treated stainless steel is not acceptable.
- M. Provide fabrication in compliance with all applicable ASTM standards or equivalent international standards.
- N. Factory welding to use shielded arc, inert gas, MIG or TIG method.
  1. Filler wire: Add to all welds to provide for a cross section equal to or greater than the parent metal.
  2. Butt welds: Fully penetrate to the interior surface and gas shielding to interior and exterior of the joint.

#### **1.06 DELIVERY, STORAGE AND HANDLING:**

- A. Manufacturer shall carefully prepare the equipment for shipment to minimize the likelihood of damage during shipment. Cavities shall be drained of water. Equipment shall be properly supported and securely attached to skids. Openings shall be covered in a manner to protect both the opening and interior.
- B. Deliver, unload, and store products on site in a manner that prevents damage. Use special care to prevent damage from temperature and condensation.

## **PART 2 - PRODUCTS**

### **2.01 SYSTEM DESCRIPTION:**

- A. Provide catenary mechanism suitable for cleaning of two existing bar rack screens (CAT-401 and CAT-402). Existing screening system capacities and operating data are indicated in the Mechanically Cleaned Screen Equipment Schedule and on PLANS.
- B. Existing screens are installed in a channel as indicated on PLANS.
- C. Service: Storm Water.
- D. Screens will discharge directly onto the open top platform as indicated.

### **2.02 MANUFACTURERS:**

- A. E&I Corporation
- B. The Fairfield Service Company
- C. Or, approved equal

### **2.03 SEISMIC DESIGN REQUIREMENTS:**

- A. The Contractor shall conform to the requirements of Seismic Design Data requirements of the current building code adopted by the City of Austin.
- B. Provide all equipment bases, anchorage, supports and foundations designed in accordance with the seismic requirements indicated and specified.
- C. Additionally, provide with the Certificate of Unit Responsibility, certification for all equipment signed by a registered structural engineer stating that computations were performed and that all components have been sized for the seismic forces specified and indicated.

### **2.04 SCREEN CLEANING MECHANISM CONSTRUCTION:**

- A. Mechanically cleaning, catenary suspended, back-discharge type inclined mechanism as indicated and specified.
- B. No changes to the existing bar rack are anticipated, other than those specified herein or on the PLANS to accommodate the installation of the proposed catenary cleaning mechanism.
- C. Screenings discharged on downstream side of screen.
- D. Framework:
  - 1. Material of Construction: 316 Stainless Steel.
  - 2. Minimum Thickness: 1/4-inch.
- E. Mounting Hardware:
  - 1. All anchor bolts shall be 316 stainless steel and be provided by the manufacturer and installed by the contractor.

2. Type 316 stainless steel with lockwashers of similar material.
3. Anchor bolts: Type 316 stainless steel.

F. Deadplate:

1. A dead plate, constructed of 316 stainless steel, shall have a minimum thickness of 1/4-inch and extend to the point of discharge. The dead plate shall include 6-inch deep side skirts to help contain the screenings. Depending on the overall width of the unit, the dead plate shall be reinforced as necessary to avoid undue bending and warping.
2. Material of Construction: Structural Type 316L.
3. Minimum Thickness: 1/4-inch.

G. Screen Rakes:

1. Each trash rake unit shall consist of raking members constructed of wide flange structural beams sized adequately to support anticipated loading. Each rake beam shall have steel counterweights welded to both sides of the web of the beam, as shown on the drawings, to provide a total minimum rake weight of 82 pounds per foot.
2. To assist in the retention of debris, each cleaning rake shall be equipped with a bolted-on, toothed retaining lip, providing the rake with a lifting shelf of at least 10 inches in width. The tooth pattern shall be triangular with each tooth face extending at least four (4) inches from the base to the apex. Teeth shall be spaced at four (4) inches on center along the width of the rakes.
3. The rake beams shall be mounted between two (2) strands of steel roller chain with the raking members equally spaced at approximately 7-foot intervals, so that all beams travel parallel to each other and at a right angle to the trash screens. The rake beams shall be attached to the chain with stainless steel bolts, nuts and washers.
4. Provide bolt on plate with teeth for all screen rakes to assist with cleaning the openings between bar racks. Contractor shall field measure the spacing between the bars on the existing bar screens to determine a tooth pattern to be provided for the rakes. Bolt on plates will be installed separately by the operator. No installation by the catenary mechanism manufacturer is needed.
5. Material of Construction: 316L Stainless Steel.
  - a. Minimum thickness: 1/2-inch.
6. Depth: minimum 10 inches beyond face of bars.
  - a. Stiffen with full length angles 3-inch x 3/8-inch or 10-inch structural channel.

H. Rake Wiper:

1. Provide rake-wiper mechanism at point of discharge, to remove materials collected on the rake if recommended by the manufacturer.
2. If provided, rake wiper to operate smoothly and without shock to wipe entire surface of rake as it passes the point of discharge.

3. Material: Type 316L stainless steel with polyethylene strips.
4. Provide shock absorbers or counterweights to control the action of the wiper.

I. Drive Sprockets:

1. The drive sprocket shall be of the shear pin type, with 11 teeth and a pitch diameter of 10.92 inches. The teeth shall be chilled to a Brinell hardness of 360 BHN for a depth of not less than 3/16 inches. The drive sprocket shall be furnished with a trip cam to activate a limit switch upon breakage of the shear pin (torque overload event).
2. The driven sprocket shall have 34 teeth and a pitch diameter of 33.33 inches. The teeth shall be chilled to a Brinell hardness of 360 BHN for a depth of not less than 3/16 inches. The sprocket shall mount on the head shaft and be held in place by a key seat and set screws.

J. Chain Sprockets:

1. Provide non-split type head-shaft sprockets with chain saver rims.
2. Rake chain sprockets shall be cast iron, chilled rim with eight (8) teeth and a pitch diameter of 23.52 inches. The teeth shall be chilled to a Brinell hardness of 360 for a depth of not less than 0.1875 inches. Head shaft sprockets shall be keyed seated and set screwed to the shaft. One idler sprocket shall be set-screwed to the shaft and the other shall spin freely and be held in place with set collars.
3. Material: Cast iron with chain saver rims.
4. Key head-shaft sprockets to drive shafts and retain idler sprockets by collars with safety set screws.

K. Shafting:

1. The head shaft and idler shaft assemblies shall be of the torque tube type, or of solid, cold-finished steel. The shafting shall be designed to adequately transfer all loads imposed under normal operating conditions without excessive deflection or distortion.
2. Type 304 stainless steel.
3. Sufficiently sized to transmit power required.
4. Shaft bearings: Double row, self-aligning tapered roller bearing pillow blocks with grease seals.
  - a. Bearing: Cast Iron.

L. Rake Chain:

1. The rake chains shall be two matched strands of steel thimble roller chain having 9-inch pitch, 3/8" thick stainless-steel side bars, and an ultimate strength of 78,000 pounds. The chains shall also have case-hardened steel thimbles, 3/4" diameter stainless steel pins, and 3 1/2" diameter straight faced, stainless steel rollers with stainless steel cotter pins. The chain pins shall be drilled and fitted with high-pressure lubrication fittings. The chain shall have attachments for the beam rakes. Rake travel speed shall be approximately 10 feet per minute.

2. Material: Welded double strand stainless steel, Type 17-4 pH stainless steel cotter pins and couplings and stainless steel side bars.
  3. Minimum pitch: 6-inch.
- M. Drive Chain:
1. The drive chain shall be 3.075-inch pitch, steel thimble roller chain with an ultimate strength of 48,000 pounds. A chain guard shall be provided to protect the drive chain and sprockets and provide a safety feature for maintenance workers.
  2. Carbon steel roller chain.
  3. Provide provisions for tightening the drive chain.
- N. Chain Guides:
1. Horizontal chain track return guides shall be provided to guide and support the rakes and chains between the idler shaft and the drive shaft. Tracks and guides shall consist of C6 x 8.2 (minimum) steel channels suitably braced and supported from the concrete structure. Similar vertical channels shall be located beneath the drive sprocket to guide the chain and rakes vertically. Return guides shall be mounted to the concrete structure using 316 stainless steel expansion anchor bolts.
  2. Material of Construction: 316 Stainless Steel.
  3. Minimum Thickness: 3/8-inch.
- O. Overload Protection:
1. Provide an electronic torque overload protection device to stop the screen and alarm on over current. Provide sheer pins to protect screen mechanisms from damage in event of torque overload device failure.
    - a. Provide contacts for screen failure (overload).
    - b. Explosion-proof Class I, Division 1, Group D.
    - c. Units incorporating the use of clutches, friction disks or similar devices, for overload protection, are not acceptable.

## **2.05 DISCHARGE CHUTES:**

- A. Provide discharge chutes for receiving and discharging material, having the dimensions as shown on PLANS and to suit the mechanically cleaned screens.
- B. Discharge Chute:
1. Structural Type 316L.
  2. Thickness: 1/4-inch.
  3. Provide all required supports.

## **2.06 SCREEN DRIVE SYSTEMS:**

### **A. Motor:**

1. Provide in accordance with Section 15172 and as specified and indicated.
2. Horsepower rating of motors: Not less than maximum brake horsepower requirements of equipment under any condition of operation specified and indicated without operating in the motor service factor.
3. Motor enclosure and motor speed: As indicated in the Mechanically Cleaned Screen Equipment Schedule in Attachment A.
4. In addition to the requirements for bearings specified under Electric Motors in Section 15172, provide pump motors with ball or roller bearings. Provide vertical motors with at least one bearing designed for thrust with bearings. Provide bearing with a minimum B-10 life of 100,000 hours.
5. Overall sound-pressure level of each motor shall not exceed 88 decibels when measured on flat network using an octave-band frequency analyzer conforming to ANSI S1.11. Determine overall sound-pressure level as average of four or more readings at evenly spaced points, 3 feet from motor.
6. Operate without overheating at the speeds specified and indicated.
7. Service Factor: 1.15.
8. Premium efficiency with nominal and minimum efficiencies per NEMA MG1
9. Rating: 460V, 3-phase, 60 Hertz.
10. Insulation: Class F with Class B temperature rise, 40degree C ambient.
11. Site Altitude: Less than 3,300 feet above sea level.
12. Integral gear reduction units are not acceptable.
13. Provide capacity sufficient to start and operate screen 100 percent blinded without exceeding nameplate ratings for current and power and without operating in the service factor.

### **B. Gear Reducer:**

1. The drive unit shall be a helical gear reducer running in an oil bath. The reducer shall have a service factor of 1.25 based on expected starting torque under expected normal operating conditions. The drive motor shall be a (minimum) NEMA, Design B, totally enclosed, fan-cooled unit. The unit shall operate on 460-volt, 3-phase power with a frequency of 60 hertz and shall not be less than 2 horsepower. The drive unit shall be capable of operating the screen chain at a speed of approximately 10 feet per minute and shall be mounted where shown on the drawings with an adjustable slide base.
2. Provide parallel shaft arrangement classified for continuous, AGMA Class II, 24-hour duty.

3. Provide ASTM A48 Class 30 cast iron housing.
4. Gears: Case hardened alloy steel forgings with precision ground gear teeth minimum AGMA quality 12.
5. Provide horizontal parallel or bevel right angle shafting, arrangement or as indicated in the Mechanically Cleaned Screen Equipment Schedule.
6. Design reducer to match output speed requirements of screens.
7. Match torque-rating of driven equipment.

**2.07 CONTROLS:**

- A. Provide controls as indicated on the PLANS and as specified in Section 13390.

**2.08 MECHANICALLY CLEANED SCREEN EQUIPMENT SCHEDULE:**

- A. Design requirements shall be as specified in Attachment "A" at the end of this Specification Section.

**2.09 SHOP PAINTING:**

- A. Primer and Finish Paint: Shop apply to all exterior ferrous surfaces, high solids epoxy in accordance with Section 09902.
- B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.
- C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

**2.10 SHOP TESTING:**

- A. Comply with the requirements as specified herein.
- B. Provide motor shop testing in accordance with Section 16800.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Installation of equipment and materials provided under this Specification Section shall be in accordance with the manufacturer's recommendations and the approved shop drawings.
- B. After alignment is correct, grout using high grade non-shrink grout.
  1. Do not imbed leveling nuts in grout.

**3.02 FIELD TESTING:**

- A. Provide a minimum of 30 days written notice to the Engineer prior to field testing.



- B. After installation of equipment, and after inspection, operation, testing and adjustment have been completed by the manufacturer's field service technician, conduct a dry running test and a performance test for each unit in presence of the Engineer to determine its ability to deliver its rated capacity under specified conditions.
- C. Screen Testing:
  - 1. Assemble each bar screen head frame with the screening ejector, the head shaft with the bearings and chain sprockets.
  - 2. Bar Screen Rack:
    - a. The bar screen rack will be checked for its dimensioning.
    - b. Verify that all bars are parallel and properly spaced.
    - c. Use a rake to move along the entire length of the bar rack.
    - d. The wear strips on which the scrapers wear shoes slide on their travel up will be installed on both sides of the bar rack.
    - e. The assembly of the bottom part of the dead plate and the top part of the bar rack will be matched together and checked for its proper assembly.
  - 3. Rake Chains:
    - a. Chains will be spread on the floor, in two match lengths, to verify the spacing of the scrapers attachments.
    - b. Both ends of each strand of drag chain will be match marked at the shop to make sure that the chains will be assembled on site in the appropriate order.
  - 4. Chain Guides:
    - a. The bottom drag chain guides will be checked for their dimensions and shipped with the UHMW wear strip installed.
    - b. The upper drag chain guides will be checked for their dimensions and shipped with the UHMW wear strip installed.
  - 5. Deadplate and Discharge Chute:
    - a. Deadplate and Discharge Chute will be attached to bar screen head frame to verify proper assembly.
    - b. Match mark to assist field assembly.
  - 6. Test screen drive system.
  - 7. Verify functionality of over torque switch.
- D. Repeat tests until specified results are obtained.

E. In event that specified tests indicate that equipment will not meet the specifications, Engineer has the right to require additional complete witnessed tests for all equipment at no additional cost to the Owner, reject the unit, or accept the unit at a reduced price.

F. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to Owner.

1. Dry Testing:

- a. Conduct test of each screen to simulate a blockage in the screen and to attempt clearing the blockage.
- b. Modified anchor bolts supplied by the equipment manufacturer shall be bolted to the screen bars for the test. The anchor bolting arrangement shall be suitable for the loads applied and simulate solids jamming the screen bars. A suitable means determined by the equipment manufacturer and acceptable to the Owner shall be employed to measure the load developed by the drive mechanism upon encountering the simulated blockage. Use the measured load to adjust the trip setting based on the recommended setting provided by the equipment manufacturer in advance of the test.
- c. Make all necessary adjustments and settings to the drive mechanism and tripping device at the time of the test to ensure that the mechanical bar screen rakes will stop at the appropriate trip setting and generate an alarm.
- d. Perform a dry test on each mechanical bar screen to demonstrate the correct alignment, smooth operation, proper and equal spacing of screen bars, freedom from vibration, excessive noise and overheating of the moving parts and bearings. Operate catenary screen cleaning mechanism for a minimum of four (4) hours in the dry condition to confirm satisfactory operation of the mechanism.
- e. Perform a dry test on each screen to demonstrate the ability of the screen to successfully handle large objects of the size and weight occasionally encountered in an unscreened stormwater system.
- f. Perform a dry test on each screen to demonstrate the ability to operate with each screen rake loaded to capacity. The loaded condition shall consist of each rake arm loaded through one full cycle of operation.
- g. All defects recorded during the above field tests and all defects and failures occurring within the first year of operation shall be corrected at no additional cost to the Owner.
- h. Dry tests on each screen shall be witnessed by Engineer.

2. Performance Test:

- a. During tests, observe and record flow rates, channel water depths, headloss, and motor inputs.
- b. Test Duration: Determined by the Engineer, but not less than 12 hours of operation during a rainfall event.

- c. Each screen must demonstrate seven (7) continuous days of defect-free operation prior to final acceptance. If the continuous operation is interrupted due to a storm event or due to events at the Waterloo Park, Contractor to keep a log and operate the screens for as long as necessary to show thirty (30) days of defect-free total run time.
  - d. Immediately correct or replace all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.
- 3. Repeat tests until specified results are obtained.
- G. Vibration tests to prove that there are no field installed resonant conditions due to misalignment and supports.
- H. Make all adjustments necessary to place equipment in specified working order at time of above tests.
- I. Promptly correct or replace all defects or defective equipment revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results that are acceptable to the Engineer are obtained. Contractor shall provide labor, material, equipment, and piping for conducting tests.
- J. Test Duration: The tests shall be conducted for a continuous period of 2 hours minimum at each speed, or until bearing temperatures are constant for 3 consecutive readings (whichever is longer) at each condition specified and indicated.

### **3.03 FIELD TOUCH-UP PAINTING:**

- A. After installation and testing with no exceptions noted by the Engineer, apply touch-up paint to all scratched, abraded and damaged shop painted surfaces. Coating type and color shall match shop painting.

### **3.04 ADJUSTING**

- A. Manufacturer's technical representative to inspect, check, assist in making adjustments if necessary, and approve for placing in operation.

### **3.05 - 3.10 (NOT USED)**

### **3.11 MEASUREMENT AND PAYMENT**

No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**ATTACHMENT "A"**

**MECHANICALLY CLEANED SCREEN EQUIPMENT SCHEDULE**

<b>Parameter</b>	<b>Catenary Mechanism Requirements</b>
Equipment Identification	CAT- 401 & CAT- 402
Number of Mechanism (Screens)	2
Screen Bay 4 Capacity – Average, cfs	1,375
Clear Opening Between Existing Bars, in	1 1/4
Rake Travel Speed, fpm	10
Rake Spacing, ft	7.00
Screen Setting Angle, deg	75
Channel Depth (Channel Invert to Operating Level), feet	32.00
Screen Depth, feet	31.00
Screen Width, feet	8.00
Screenings Discharge Height, feet (Above Operating Level) (Min)	3.5
Screenings Discharge Height, feet (Above Channel Invert)	35.5
Water Depth Upstream of Screen, feet	483.06
Motor Hp	2
Motor Speed, rpm	2
Motor Enclosure	Explosion Proof

**END OF SECTION**

## **SECTION 13390**

### **PACKAGED CONTROL SYSTEMS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Scope of Work
  - 1. Furnish, install, and place in service the packaged control systems as shown on the PLANS and as specified hereinafter.
  - 2. The subsequent document entitled "Appendix A – Packaged System PLCs Programming Criteria" is hereto made part of this section and includes OWNER'S requirements associated with the programming of the packaged control system PLC(s) and other project requirements. Coordinate with the OWNER'S and comply with the OWNER'S latest programming requirements. The contents of "Appendix A" are not inclusive of all requirements of this Contract. Refer to the PLANS and other Sections of the Specifications for additional information
  - 3. The subsequent document entitled "Appendix B – AW Host Pack Spreadsheets" is hereto made part of this section and includes OWNER'S requirements associated with the AW Host Pack spreadsheets. Coordinate with the OWNER and comply with the OWNER'S latest Host Pack spreadsheet requirements. The contents of "Appendix B" are not inclusive of all requirements of this Contract. Refer to the PLANS and other Sections of the Specifications for additional information.
  - 4. The subsequent document entitled "Appendix C – AW Software Tagging Criteria" is hereto made part of this section and includes OWNER'S requirements associated with the software tagging within PLC/OIU programs. Coordinate with the OWNER and comply with the OWNER'S latest tagging criteria requirements. The contents of "Appendix C" are not inclusive of all requirements of this Contract Refer to the PLANS and other Sections of the Specifications for additional information.

##### **1.02 RELATED WORK**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

### **1.03 QUALIFICATIONS**

- A. Panels associated with the Packaged Control System (PCS) shall be designed, constructed, and tested in accordance with the latest applicable requirements of ISA, NEMA, ANSI, UL, and NEC standards. Panels shall be designed, constructed, and tested by a UL508 certified entity.
- B. Assemble panels in equipment manufacturer's factories. Test panels for proper operation prior to shipment from the manufacturer's factory.

### **1.04 DELIVERY, STORAGE AND HANDLING**

- A. Protection
  - 1. The Contractor, and hence the PCS supplier, shall be responsible for safety of the PCS during storage, transporting and handling.
  - 2. The PCS equipment shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment.
  - 3. At all times the PCS equipment shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.
  - 4. Interior and exterior of PCS equipment shall be kept clean at all times.
  - 5. Energize the space heaters within the PCS and energize during storage and installation for humidity control.
- B. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:
  - 1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:
    - a. Ambient Dry Bulb Temperature:
      - 1) Minimum: 68 degrees Fahrenheit.
      - 2) Maximum: 85 degrees Fahrenheit.
    - b. Ambient Relative Humidity: Maximum: 50%.
    - c. Ambient Corrosion Level: International Society of Automation Class: G1
  - 2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.
  - 3. Upon arrival of equipment onto job site, the Contractor shall provide proper transition of power to equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational and that the equipment is in a conditioned space on the day the equipment arrives.
  - 4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

## 1.05 SUBMITTALS

- A. Submit shop drawings in accordance with the requirements of Section 01300 of the Contract Specifications. Include:
  - 1. Dimensioned/scaled top and bottom enclosure views, front enclosure elevations, and internal component/device layouts
  - 2. One-line diagrams and wiring diagrams, as applicable,
  - 3. Catalog cut sheets. Include protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable. Include color chart for control panel color selection by the OWNER.
  - 4. Additional information as described in Appendix A – Packaged System PLCs Programming Criteria.
- B. Where Programmable Logic Controllers (PLCs) are provided as part of the PCS (refer to Section 2.03, this Section of the Specifications), submit PLC programming documentation in accordance with the requirements of Section 01300 of the Contract Specifications. Include:
  - 1. PLC program input/output point listing, including all PLC software input/output points obtained through all serial communication interfaces. Include points obtained from the OWNER's Distributed Control System that are necessary for proper operation of the PCS. Multiple submittals of this listing will be required to facilitate the PLC programming coordination specified herein. The input/output point listing shall be provided electronically in Microsoft Excel format. The input/output point listing shall be submitted along with the product data. Submittals excluding the input/output point listing shall not be accepted. At minimum, the following shall be identified in the input/output point listing for each input/output point:
    - a. Register Address: The PLC register address associated with the point
    - b. Tag Name: the tag name as assigned in the PLC program for the data point
    - c. Description: the description of the data point
    - d. Data Type: the data type as used in the PLC program (integer, floating point, etc.)
    - e. Origin. For those points transmitted via a serial communication network, the PLC identifier and its associated register address
    - f. Terminal block locations.
    - g. Additional supplementary information as recommended by the packaged control system manufacturer to enhance the understanding of the i/o listing.
  - 2. Submit a Plant Control System interface table in electronic Microsoft Excel file format. The Plant Control System interface table is to consist of only those data points in the packaged system vendor's PLC data registers that are to be shared with the OWNER'S Top-End computer system and/or PLC system via the Modbus/TCP communication with the packaged control system PLC. This plant control system interface table should consist of ONLY points that are intended to be shared with the plant control system (Plant PLC's and plant SCADA computers). These data points should include, in particular, equipment status (e.g., on/off), process values (e.g., pressure, level, flow, etc.), equipment mode (e.g. manual/auto or lead/lag), alarms, data points associated with the protective relays/power monitoring units and telemetered through the Modbus/TCP communication data link connected to the PCS (minimum points

as described hereinafter), and additional data points that are available to or can be developed by the PCS as requested by the Owner. The table should also include control commands and setpoints (if appropriate and as deemed fit by the vendor). No other data points, e.g. internal/temporary registers, should be listed in this table. The quantity and type of input/output points to be made available to the OWNER'S Distributed Control System through the serial communication interfaces will be determined after Bid Award. Provide the input/output points as requested by the OWNER at No Additional Charge to the OWNER. The Plant Control System interface table is to consist of the following columns:

- a. Register Address: The PLC register address associated with the point
  - b. Tag Name: the tag name as assigned in the PLC program for the data point
  - c. Description: the description of the data point
  - d. Data Type: the data type as used in the PLC program (integer, floating point, etc.)
  - e. EGU Min: Minimum value for data point (for non-Boolean values). It is assumed the point is scaled to the engineering units (EGU) value in the vendor PLC for use by the plant control system
  - f. EGU Max: Maximum value for the data point (for non-Boolean values). It is assumed the point is scaled to the engineering units (EGU) value in the vendor PLC for use by the plant control system.
  - g. EGU: engineering units used (for non-Boolean values).
  - h. Bool 0 Desc: The description of the Boolean point when it is Boolean 0
  - i. Bool 1 Desc: The description of the Boolean point when it is Boolean 1
  - j. Alarm Priority: The alarm priority (for alarm points only) is to be one of H, M, or L, where H = High priority alarm, M = Medium priority alarm, L = Low priority alarm
  - k. Direction: The direction is to be one of R, W, or RW, where: R = Data is read by the plant control system from the vendor PLC, W = Data is written by the plant control system to the vendor PLC, RW = Data is read and written by the plant control system from/to the vendor PLC
  - l. Discrete Commands from plant HMI to PLC: If any discrete command bits are required from the plant HMI control system to the PLC, then the PLC will reset the command bit to zero at the end of each PLC scan. The command is to take action in the vendor PLC on Boolean 1, and have no action in the vendor PLC on Boolean 0.
  - m. All alarms shall be Boolean such that 0 is the normal condition and 1 is the alarming condition
  - n. Heartbeat Register in each PLC: For each PLC, please provide a heartbeat register that increments once every 0.1 seconds, is of Type INT and has a range of 0 to 32767
  - o. Boolean Status Points: Map all 0x (%M) register Boolean points to 4x registers (%MW) words of WORD data type and provide indexing into the 4x register to attain the Boolean value. All equipment on/off statuses shall be Boolean such that 0 = OFF, 1 = ON
3. Completed AW Host Pack spreadsheets. The OWNER will furnish Host Pack spreadsheets electronically in Microsoft Excel format. Include effort to coordinate with the OWNER related with the Host Pack spreadsheets and submit the completed Host Pack spreadsheets in electronic Microsoft Excel file format. The formatting of the Host Pack spreadsheets may not be altered



without prior approval from the OWNER. Refer to Appendix B – AW Host Pack Spreadsheets for additional requirements for bidding purposes.

4. Minimum data points to be telemetered by the PCS for protective relays/power monitoring units that are connected to the PCS are as follows: Voltage (average, A-B,B-C,C-A), Current (average, A, B, C, Ground), power factor, horsepower, kw, kvar, kva, mwh, and all alarms and trip conditions that are configured on the protective relay/power monitoring unit.
  5. Electronic files of PLC program in editable electronic files and PDF on CD-ROM. Follow the file format as described hereinafter.
  6. Electronic files of the OIU screens in editable electronic files (Schneider Electric Vijeo \*.vdz file format) and PDF on CD-ROM. Follow the file format as described hereinafter.
  7. Additional information as described in Appendix A – Packaged System PLCs Programming Criteria.
- C. Sequence of operation. In addition to the operation of the PCS, include the OWNER's process/mechanical equipment that shall also be monitored/controlled by the PCS, where applicable.
- D. Testing Related Submittals:
1. Submit ORT test procedures and test results per Section 17100.
  2. Submit PAT test procedures and test results per Section 17100.
- E. Certified Report: Submit a report prepared by PCS Manufacturer's technical representative certifying satisfactory installation, operation, and in service placement of entire PCS.

## **1.06 OPERATION AND MAINTENANCE MANUALS**

- A. Furnish Operation and Maintenance Manuals in accordance with the requirements of Section 01730 of the Contract Specifications. Include:
1. Installation and operation manuals
  2. Renewal parts bulletin
  3. As built drawings, including approved shop drawings
  4. Test data
  5. Software program hardcopy (as applicable) for final as-built software
  6. Additional information as described in Appendix A – Packaged System PLCs Programming Criteria

## **1.07 TOOLS AND SPARE PARTS**

- A. Furnish the following spare parts with the equipment for each PCS in conformance with the specifications:
1. One (1) – Set of fuses (minimum 3) for each type and size used for fuses 110V and greater.
  2. One (1) – Set of starter contacts for every three (3) like starters used (a minimum of 1 for each size used). If contacts are not replaceable a spare starter for each size used shall be supplied.
  3. One (1) - Contactor coil for every NEMA size and type starter installed; a minimum of one coil per size.

4. One (1) - Spare control relay, complete with all accessories, for each relay type used.
5. One (1) - Spare timing relay.
6. One (1) – Sets of overload heaters for each size and type used.
7. One (1) – Selector switch, complete with 2 auxiliary contacts, of each type used (two position, three position, etc.).
8. One (1) – Pilot light, complete with auxiliary contact, of each type used.
9. One (1) - Push button, complete with auxiliary contact, of each type used.
10. Ten percent - terminal blocks, of each type and color used.
11. Ten percent – PLC input/output modules, with minimum of two of each module type used.
12. Ten percent – PLC CPU and Ethernet networking modules, with minimum of one of each module type used.
13. Ten percent – PLC CPU memory cards, with minimum of five of each type used.
14. Ten percent – Ethernet switches, minimum of one of each type used.
15. Ten percent – OIU, with minimum of one of each type used.
16. One (1) spare PLC rack of each type used.
17. One (1) spare power supply of each type of power supply (24VDC, etc.) used.

## **1.08 SPECIAL MANUFACTURER SERVICES**

- A. Where PLCs are provided as part of the PCS (refer to Section 2.03, this Section of the Specifications):
  1. The PCS Manufacturer shall include, at minimum, four (4) meetings dedicated for the purpose of coordinating PLC programming and OIU screen development. The meetings shall be conducted to assist in the coordination effort needed to interface the PCS with the OWNER's Distributed Control System, inclusive of all the OWNER's PLCs and Top-End (host) computer system, and coordination of PCS PLC algorithm development and OIU screens where required to achieve the overall functional requirements of this Specification. The PCS Manufacturer shall provide a non-sales type representative to attend each meeting who is also intimately familiar with the PLC programming of the PCS. For bidding purposes, each meeting shall have a four hour duration and be held at the OWNER'S project site. At each meeting, the PCS Manufacturer shall also provide a submittal of the PLC program input/output point listing, sequence of operation, and electronic files of the PCS PLC program developed to date. Refer to the Submittals section of this Specification for minimum composition of input/output point listing, sequence of operation, and electronic PLC program files. The PCS Manufacturer shall include all necessary travel, submittal reproduction, and miscellaneous other expenses associated with their meeting attendance.
  2. PLC software registers associated with the input/output point types (i.e., discrete input, discrete output, analog input, analog output) that are telemetered to the OWNER's distributed control system shall be organized contiguously among each input/output point type.
  3. In the software programming, adhere to the software tagging as described in "Appendix C – AW Software Tagging Criteria" to the extent practicable. Coordinate software tagging with the OWNER.

- B. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to advise the Contractor in the installation of the equipment and assist in all PCS testing and start-up. Include checking alignment of parts, wiring connections, operation of all panels, parts (relays, starters, PLCs, etc.). Include time to correct and recheck any discrepancies which are discovered. Also include providing the OWNER with a report certifying that the equipment was installed, properly tested, and set in accordance with the PCS manufacturer's requirements and is in satisfactory operating condition. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications.
- C. Any problems encountered with the operation of equipment, parts, components, etc. installed within the PCS shall be repaired/remedied by the manufacturer's technical representative.

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

- A. Furnish and install all necessary components and wiring for a complete and functional system. Furnish and install additional requirements as follows:
  - 1. Furnish and install the enclosure as hereinafter specified. Mount and wire all components inside of enclosure unless specified otherwise. The enclosure, with all components mounted and wired, complete with all accessories, shall be referred to hereinafter as the Control Panel.
  - 2. Furnish and install the Control Panel configured for single point electrical feed that terminates on a dedicated main circuit breaker inside of the Control Panel. Refer to the PLANS and also the appropriate Division 11 Specification for which the PCS is provided for voltage and phase requirements. The Control Panel shall contain all necessary means, i.e. , control power transformer with primary and secondary short circuit protection/disconnects, uninterruptible power supply, associated wiring, short circuit protection, etc. to derive and distribute the needed control power at the necessary voltages for the entire PCS.
  - 3. Furnish and install the control system Type as hereinafter specified.
  - 4. Furnish and install motor starters/drives as specified herein, by other Sections of the Specifications, and the PLANS. Size, furnish, and install motor starters/drives complete with all accessories as specified.
  - 5. Furnish and install circuit breakers for branch circuits distributed from Control Panel as hereinafter specified. Coordinate operation of branch circuit breakers with corresponding main circuit breaker for proper circuit isolation and protection. Note, the main circuit breaker for the control panel per paragraph 2.01.A.2 shall not be considered a branch circuit breaker for the purposes of this Specification.
  - 6. Furnish and install field devices that are fully corrosion resistant, water tight, and resistant to all chemicals associated with the process application. All field devices life cycle, operation, and accuracy shall not be affected by the process application. As a minimum, all field devices shall be U. L. Listed and NEMA 4X rated. The mounting arrangement shall include provisions to enhance operation and maintenance of the system in consideration of the process application.

7. Where devices are required for the functional operation of the PCS but are not specified under Division 17, furnish and install manufacturer's standard.
  8. Where process taps/connections are located higher than 5 feet above finished floor/grade, furnish and install remote mounted indicating transmitters and extend tubing as required to facilitate mounting transmitters no higher than 5 feet above finished floor/grade.
  9. For additional construction notes and special requirements, refer to the PLANS and the Specifications.
- B. Analog, Control, and Alarm Signaling Requirements
1. Refer to the PLANS and also the appropriate Division 11 Specification for which the PCS is provided for minimum contacts to be connected to the OWNER's Distributed Control System.
  2. All control and alarm circuits shall be 120 volts A.C. Alarm signal contacts shall open to alarm and shall be isolated contacts rated for 5 ampere at 120 volts A.C.
  3. The contact configuration (normally open/closed) required for proper interface to the OWNER's Distributed Control System shall be furnished and installed at No Additional Cost to the OWNER. Under no circumstances shall contacts of pushbuttons and selector switches be connected to the OWNER's Distributed Control System via interposing relays. Refer to Section 17600 for minimum interface requirements to the OWNER's Distributed Control System.
  4. All analog signals shall be 4 to 20 mA DC. Use "two-wire" type circuits where possible. Furnish and install loop current isolators for each analog signal circuit in which either the field device or Control Panel is located outdoors. Loop current isolators shall be per Section 17200.
  5. All RTD signals shall be 100 ohm platinum type.
- C. Selector Switches, Pilot Devices, Pushbuttons requirements:
1. For NEMA 12 rated enclosures: Furnish and install per Section 17200.
  2. For NEMA 4X rated enclosures: Furnish and install per Section 16540.
  3. Mount on enclosure door.
- D. Wiring: Furnish and install as specified in Section 17200 and 17600. Group conductors and route in wireways as specified in Section 17200. Wire insulation pigmentation for 480 VAC circuits shall be per Section 16200. Field wiring shall be per Section 16200.
- E. Identification: Tag enclosure, terminal blocks, and devices (mounted interior and on the face of the enclosure) as specified in Section 17200. Tag all wiring per the requirements of Section 16200.
- F. Grounding: Furnish and install grounding per Section 17200.
- G. Miscellaneous Accessories:
1. Furnish and install lugs/ power distribution blocks /terminal blocks as required for the connection of the field wiring. Furnish and install terminal blocks per Section 17200. Furnish and install the necessary means for the termination of the field wiring at No Additional Cost to the OWNER.
  2. Furnish and install a Type 2 surge protective device for the 120 VAC package control system control power circuitry. Wire, and mount inside the enclosure.

3. Furnish and install 24 volts DC power supply and all other power supplies per the PCS manufacturer's requirements where not specified per Section 17200. Wire and mount inside the enclosure.
  4. Where an uninterruptible power supply is needed for the application, furnish and install per Section 17200. Packaged control systems having PLCs shall also be furnished with uninterruptible power supplies per Section 17200.
  5. Arrange the enclosure internal components to coordinate with the OWNER's conduit entry requirements at No Additional Cost to the OWNER.
  6. Where junction/pull boxes are required, furnish and install per Section 16250.
- H. All outdoor located enclosures and field indicators/transmitters shall also have a sunshield hood per Section 17380 and as detailed on the PLANS, with the following exceptions:
1. PCS manufacturer to adjust the sunshield dimensions as necessary to coordinate with the dimensions of the control panel/instrument.
  2. The hinged flap detailed on the PLANS is not required for control panels.
  3. Orient as described on the PLANS and coordinated with the Owner.

## **2.02 CONTROL PANEL ENCLOSURE REQUIREMENTS**

- A. Enclosure shall be the totally enclosed, dead front, suitable for back-to-wall mounting. Free standing and wall mounted enclosures may be used. Enclosure shall be adequately sized to contain all of devices required for the PCS in addition to facilitating the termination and routing of all associated PCS field interconnect conduit/wire systems.
- B. Unless specifically noted otherwise elsewhere, enclosures shall be rated:
1. Enclosures located outdoors: NEMA Type 4X, Type 316 Stainless Steel enclosures. Enclosures shall have a smooth, non-brushed finish.
  2. Enclosures located indoors in process/mechanical areas and storage areas that are not environmentally and climate controlled: NEMA Type 4X, Type 316 Stainless Steel enclosures.
  3. Enclosures located indoors in areas that are environmentally and climate controlled: NEMA 12-gasketed, painted steel enclosures per Section 17200.
- C. Enclosure shall have hinged, gasketed doors. Each door shall have an operating handle. At minimum, Furnish and install quarter turn door latch. Furnish and install three point door latch where available for the enclosure. Furnish and install pad locking means for the door/handle.
- D. Enclosures shall have a door mounted variable depth disconnect operating mechanism for operating the main circuit breaker and providing access to the 480V compartment. Provide padlockable disconnect operating handle. Handle shall be mechanically interlocked with the door/barrier to prevent personnel from opening the door and accessing the 480V compartment when the unit disconnect is in the ON position. Furnish and install handle-door interlock defeating (bypass) feature. Disconnect operating mechanism shall be as manufactured by Square D Class 9421 or approved equal. Electric actuated door interlock means will not be accepted.

- E. When sizing the enclosure, consideration shall be given to the enclosure installation location and the environmental aspects associated with the location (indoors, outdoors, etc.). Enclosures shall be sized to adequately dissipate heat generated by the equipment contained therein. Enclosures shall be provided with the necessary climate control devices, i.e. air conditioners, cooling fans, thermostatically controlled heaters, as required, for proper PCS operation. All outdoor located enclosures containing PLCs shall have air conditioners as hereinafter specified.
- F. Furnish and install enclosure manufacturer's factory interior backpanels and sidepanels as required to facilitate interior device mounting. Panels shall be factory painted white.
- G. For all PCS enclosures containing components rated greater than 120 VAC and components rated 120 VAC and less, the enclosure shall consist of two compartments. Each compartment shall have an independently operating door. A barrier shall extend the full height and depth of the enclosure to separate the two compartments and isolate power and control components rated 120 VAC and less from all components rated greater than 120 VAC.
- H. The following are required for all outdoor enclosures containing PLCs and for indoor enclosures containing PLCs that are located in Process/Mechanical areas and Storage areas that are not environmentally and climate controlled:
  - 1. Air Conditioner:
    - a. Sizing and Quantity: Provide the size and quantity of units as required for the application environment.
    - b. Type: Thermostatically controlled packaged closed-loop air conditioner climate control unit surface mounted to the exterior side of the control panel. Suitable for use in an outdoor corrosive environment and also rated Class 1 Division II.
    - c. Material: NEMA 4X, Type 316 Stainless Steel enclosure suitable and rated for use in corrosive environment, 16-gauge minimum thickness. Internal components shall be coated for corrosion protection.
    - d. Electrical Service: Connect to the PCS single point electrical service via a dedicated circuit breaker.
    - e. Controls:
      - 1) Provide air conditioner manufacturer's standard air conditioning system package control system for the air conditioner. The air conditioner shall have the capability to be controlled by the industrial thermostat specified hereinafter.
      - 2) Each air conditioner shall include low ambient controls to allow the unit to operate down to 0 degrees Fahrenheit ambient conditions.
      - 3) Provide a dedicated thermostat for each air conditioner. The thermostat shall be per Section 17200. The thermostat for each air conditioner unit shall be mounted inside the cabinet.
    - f. Accessories:
      - 1) Condensate Management System: Each air conditioner unit shall have a condensate management system that evaporates moisture from the enclosure into the condenser air stream and shall not require disposal of liquid condensate and shall not cause build-up or spillage of liquid condensate.

- 2) Air filters: Field replaceable aluminum filters.
  - 3) Extension frame with self-contained Drip Pan Tray
  - 4) Mounting gaskets and hardware for a complete installation
  - 5) Reinforce the cabinet enclosure as required to support the air conditioner.
- g. Manufacturer: EIC Solutions, or approved equal.
2. Cabinet Interior Insulation:
  - a. General:
    - 1) Provide insulation for interior of cabinet to the extent practicable to reduce heat transfer.
    - 2) Install in accordance to manufacturer requirements, minimize the number of duct board sections and provide no gaps between sections
    - 3) Install with cleanable aluminum foil (FRK) facing on exposed surface such that no bare fiberglass surface is exposed or visible. Install panels and other equipment onto cabinet such that insulation is not compressed.
    - 4) Securely fasten duct board onto cabinet interior surface with adhesive with 100 percent coverage of adhesive at board fiber side contact with cabinet inner surface area.
    - 5) Where heat dissipating device or other device is mounted onto cabinet panel, provide a 1-inch gap between duct board and device or as required to allow proper operation of device per device manufacturer requirements.
    - 6) Neatly cut duct board to provide a clean finished appearance.
  - b. Material: 1-inch thick fiberglass duct board having a rigid resin bonded and flame retardant fibrous glass board with a damage-resistant reinforced aluminum foil (FRK) facing
  - c. Thermal Conductivity: (K at 75 degrees Fahrenheit) no greater than 0.23 BTU-inch per hour foot-squared degree Fahrenheit.
  - d. Adhesive, tape, and duct board installation shall comply with NFPA 90A or NFPA 90B and UL 181A and ASTM C 916.
  - e. Manufacturer: Owens Corning series QuietR or approved equal
  - f. Accessories:
    - 1) Tape: Aluminum foil / scrim / kraft (FSK) 3-inch minimum width non-tearable with diamond patterned backing, a rubber based adhesive system, and shall meet requirements of UL 723 and as manufactured by Shuretape or approved equal.
3. Space Heater:
  - a. Sizing and Quantity: Provide the size and quantity of units as required for the application environment.
  - b. Type: Thermostatically controlled. Provide a dedicated thermostat for the space heater. The thermostat shall be per Section 17200. The thermostat shall be mounted inside the enclosure.
4. Interior Enclosure Ambient Air Temperature Transmitter: Furnish and install a temperature transmitter to monitor the interior cabinet ambient air temperature. Transmitter shall be per Section 17380. Although not shown on the PLANS, connect the 4-20mA DC analog output from the transmitter to the packaged control system PLC for remote monitoring by the OWNER'S Distributed Control System. The internal cabinet ambient air temperature shall be visible exterior of the cabinet, regardless if the temperature value is displayed on any

OIU screen. Furnish and install a discrete digital indicator as required to display the internal cabinet ambient air temperature.

- I. Furnish and install the following additional accessories for each enclosure:
  - 1. For each door:
    - a. Grounding bonding jumper.
    - b. Door stop kit.
    - c. 12-inch door data pocket.
  - 2. For free standing enclosures:
    - a. Furnish and install light fixture per the requirements of Section 17200.
    - b. Furnish and install wire convenience receptacle per the requirements of Section 17200.
    - c. Furnish and install lifting eyes.
  - 3. Furnish and install all additional enclosure accessories, mounting hardware, 19 inch rack accessories, etc., as required for a functional PCS.
  - 4. Additional requirements for indoor enclosures located in areas that are environmentally and climate controlled: Furnish and install enclosure complete with all accessories per Section 17200.
- J. Enclosures shall be as manufactured by:
  - 1. All outdoor enclosures and indoor enclosures located inside process/mechanical areas and storage areas that are not environmentally and climate controlled:
    - a. Wall mounted control panel: Hoffman Concept Stainless Steel 4X Wall Mounted Enclosure Series with CWHPTO Padlock Handle, or approved equal.
    - b. Free Standing control panel: Hoffman Free-Standing Single and Dual Access with 3-Point Latches and Lockable Powerglide® Handles, Type 4X Enclosures, or approved equal.
  - 2. Indoor enclosures located inside environmentally and climate controlled areas: Furnish and install per the requirements of Section 17200.

## **2.03 PACKAGED CONTROL SYSTEM TYPES**

- A. The PCS shall use one of two types of control system types to implement the packaged control system functionality as follows:
  - 1. Type A: At minimum, this type shall employ the use of PLCs as described hereinafter. PLCs in combination with hardwired relay logic may be used at the PCS Manufacturer's discretion.
  - 2. Type B: This type shall only employ the use of hardwired relay logic. This control system type shall not include the use of PLCs whatsoever. Additionally, any type of micro-processor based programmable relay, any relay requiring software download, or any other type of similar programmable relay shall not be used. As technology advances over time, similar appearing devices are subject to review and approval by the OWNER after Bid Award and the PCS Manufacturer shall incorporate the OWNER's request at No Additional Cost to the OWNER.



B. Additional requirements for Type A systems only:

1. General:

- a. The type of PLC (Type 1 or 2) as hereinafter specified shall be selected by the PCS Manufacturer to meet the functional requirements of this Specification and also the appropriate Division 11 Specification for which the PCS is provided. Additional types of PLCs beyond those listed here shall not be accepted.
  - 1) Type 1: Furnish and install Type 1 PLCs as specified in Section 17600.
  - 2) Type 2: Furnish and install Type 2 PLCs as specified in Section 17600.
- b. All equipment shall be furnished and installed complete with all necessary software.
- c. As a minimum, the PCS shall communicate with the equipment as shown on the control system architecture, in addition to the OWNER'S Top-End computer system. Program the PCS accordingly.

2. Operator Interface Unit (OIU):

- a. Furnish and install OIU as specified in Section 17600
- b. If a specific type of OIU is not shown on the PLANS or Specifications, the default type shall be Type 1.
- c. Furnish and install the additional quantities of OIUs as may be required by the PLANS or Specifications.
- d. Mount OIU on enclosure door, providing additional enclosure accessories (window kit, etc.) as needed to achieve appropriate NEMA rating.
- e. Furnish and install a sun shield as specified in Section 17380 for all OIUs installed on enclosures located outdoors.

3. Miscellaneous:

- a. Furnish and install the Ethernet switches, patch panels, and related hardware/accessories as specified in Section 17600 and as shown on the PLANS to facilitate the network data connections of the PCS to the OWNER's Distributed Control System.
- b. Although not shown on the PLANS, furnish and install one 120Vac, 1P-20A GFI convenience receptacle and 1 Cat 5e Ethernet data port receptacle with NEMA 4X rated hinged UV resistant clear polycarbonate cover. Receptacles shall be accessible from control panel exterior without requiring access to internal control panel components. Wire receptacles to Ethernet switch and control power supply of internal control panel. Furnish and install receptacles as manufactured by Hubbell "Panel-Safe", model PR4X205E or approved equal.
- c. Furnish and install additional 25 percent excess capacity over the number of inputs, outputs, and other necessary functions.

C. Requirements common to Types A and B systems:

1. Refer to the PLANS and also the appropriate Division 11 Specification for which the PCS is provided for the control system type.
2. Furnish and install control relays and timing relays as specified in Section 17200.

## 2.04 MAIN AND BRANCH FEEDER CIRCUIT BREAKERS

- A. Furnish and install thermal magnetic molded case circuit breakers. Size per NEC. Circuit breakers shall have U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the bus serving the equipment, unless noted otherwise on the PLANS or in the Division 11 Specifications. Unless shown otherwise, the minimum RMS symmetrical short circuit current rating shall be 42kA at 480 volts A.C.
- B. Furnish and install where specifically shown on the PLANS or for proper circuit protection/coordination:
  - 1. Current limiting circuit breaker.
  - 2. Electronic trip attachment. Trip unit shall be solid state type with field adjustable long time, short time, ground fault and pick up settings.

## 2.05 MOTOR STARTERS AND VARIABLE FREQUENCY DRIVES

- A. Each combination motor controller and feeder unit shall have the following characteristics:
  - 1. General:
    - a. Comply with the control logic requirements of the PCS manufacturer.
  - 2. Molded case circuit breakers for branch circuit protection. Circuit breakers shall have the following characteristics:
    - a. Shall have U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the bus serving the equipment, unless noted otherwise on the PLANS or in the Division 11 Specifications. Unless shown otherwise, the minimum RMS symmetrical short circuit current rating shall be 42kA at 480 volts A.C.
  - 3. Starters shall have the following characteristics:
    - a. Starters shall be magnetic type, NEMA rated, with 120 volts A.C. operating coils. International type starters (IEC rated), will not be accepted, even if the starters were to show equivalent NEMA ratings.
    - b. Size and configuration (full voltage non-reversing, full voltage reversing, etc.) as required for the application. Size per NEC and provide minimum of NEMA Size 1.
    - c. Provide each starter coil with the manufacturer's standard transient voltage surge suppression module.
    - d. Provide auxiliary contacts as required by the PLANS. Contacts shall be rated for 120 volts A.C and shall satisfy the requirements of the PLANS. Provide each starter with one (1) normally open auxiliary contact wired to terminal blocks over the number of contacts required by the PLANS.
  - 4. Provide Overload relays. Overload relays shall have the following characteristics:
    - a. Standard class 20, ambient compensated,
    - b. Manually reset by push-button located on front of the compartment door.
    - c. Provide with auxiliary contact rated for 120 volts A.C. Contact shall satisfy the requirements of the PLANS.
    - d. The overload relay heaters will be selected by the Contractor after delivery of the MCC. Include all necessary delivery, packaging, and administrative costs associated with the delivery of overload heaters.

5. Control Power Transformer:
  - a. Dedicated control power transformer for each motor starter is not required. Serve starter control power from PCS control power distribution per the manufacturer's standard.
6. Power Factor Correction Capacitors (PFCCs):
  - a. Furnish and install PFCCs for all constant speed motors sized three horsepower and larger. Exception: Motorized valves and reversing/jogging process applications do not require power factor correction capacitors.
  - b. Connect capacitors between the motor starter and the overload relay.
7. Provide one single pole fuse block with fuse for each motor space heater.
8. Variable Frequency Drives:
  - a. Each variable frequency drive starter assembly shall include a NEMA rated main output contactor that is electrically interlocked with the VFD controller and full voltage bypass starter. The VFD shall have a micro-processor based controller equipped with the manufacturer's standard features for protection, operation, and data acquisition of a VFD system. The operation of the controller shall also be coordinated with the operation of the Owner's existing distributed control system logic. Provide supplementary control relays and interlocks as required for the proper interconnection and operation of the VFD with the Owner's existing distribution control system logic.
  - b. Each VFD shall be a 6-pulse Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to variable voltage and frequency output. The manufacturer shall supply 6-Pulse bridge rectifier design, at minimum. The VFD shall connect to an externally mounted drive isolation transformer, where required.
  - c. Each VFD shall be UL 508C tested.
  - d. Incomplete sequence protection of each VFD main output contactor shall be provided with interlocking circuitry to fault the VFD should the contactor fail to close when commanded.
  - e. The VFD section containing the VFD shall have a minimum of one (1) door mounted ventilation fan rated at 120VAC, thermostatically controlled, fused, and wired to the control power transformer. Ventilation fan to provide positive forced air ventilation of MCC section containing the VFD. Provide dedicated thermostat for each VFD. Furnish additional ventilation fans as required in accordance with VFD Manufacturer's recommendations to provide for proper VFD heat exchange.
  - f. The VFD section shall also be supplied with a high ambient temperature switch separate from the fan control thermostat to detect excessive VFD section temperature. Wire switch contacts to shut down the VFD and telemeter a common alarm to the Owner's existing distributed control system.
  - g. Each VFD shall be designed to operate in an ambient temperature from 0 to 40 degrees Celsius.
  - h. Each VFD shall be designed to operate from an input voltage of 480 plus or minus 15 percent VAC.
  - i. Each VFD shall operate from an input voltage frequency range of 60 Hz with plus or minus 2 percent.
  - j. The displacement power factor shall not be less than 0.975 lagging under any speed or load condition.

- k. The efficiency of each VFD at 100 percent speed and load shall be greater than or equal to 95 percent.
- l. Drive family (Constant torque, variable torque, etc.) to be selected by the Division 11 equipment manufacturer.
- m. The VFD minimum output current shall be as determined by the Division 11 equipment manufacturer.
- n. The control logic drawings in the PLANS show the minimum requirements for the VFD. Furnish additional controller contact inputs/outputs, interposing relays, selector switch contacts, fused power supplies, etc., as required to facilitate VFD operation.
- o. A digital terminal keypad shall be provided with each starter/controller for viewing of electrical values, configuration of parameters, I/O assignments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics. The terminal keypad will consist of programmable function keys. The functions will allow both operating commands and programming options to be preset by the operator. The Keypad shall be rated NEMA Type 12 and be mounted to the face of the VFD.
- p. Furnish and install VFD with harsh environment UL 746 recognized conformal coating for all printed circuit assemblies.

## **PART 3 EXECUTION**

### **3.01 FACTORY INSPECTION AND TEST**

- A. Each control panel shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop test and any other additional operational test to insure the functionality, workability and reliable operation of the equipment.
- B. Size, furnish and install the overload relay heaters based on actual motor nameplate current. Set overload relay settings at maximum values permitted by the NEC 430-32.
- C. Size, furnish and install the motor space heater fuses based on actual motor space heater load current.

### **3.02 FIELD INSTALLATION (BY CONTRACTOR)**

- A. Mount all PCS subcomponents as shown on the PLANS and as recommended by the PCS manufacturer.
- B. All field wiring shall be tagged per the requirements of Section 16200. Secure wiring in control panel with plastic ties. Arrange wiring neatly, remove surplus wire, and install abrasion protection for wiring passing through holes or near edges of sheet metal.
- C. Clean and vacuum all interior of the equipment. Touch-up and restore damaged surfaces to factory finish.

### **3.03 FIELD TESTING**

- A. After field installation of the PCS and prior to energizing any of the process/mechanical equipment controlled by the PCS:
  - 1. Conduct an ORT for the PCS per Section 17100. Submit test results for review and approval. Prior to conducting the ORT, meet all prerequisites associated with conducting the ORT as described in Section 17100. The OWNER may elect to witness the ORT. Coordinate with the OWNER accordingly.
  - 2. Conduct a PAT for the PCS per Section 17100. Submit test results for review and approval. Prior to conducting the PAT, meet all prerequisites associated with conducting the PAT as described in Section 17100. Exception: As the application software for the PCS is provided by the PCS manufacturer, the PCS manufacturer shall lead the PAT software test activity.

### **3.04 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

## **SECTION 13390**

### **APPENDIX A - PACKAGED SYSTEMS PLC PROGRAMMING CRITERIA**

#### **PART 4 PACKAGED SYSTEMS PLC PROGRAMMING CRITERIA**

##### **4.01 GENERAL**

- A. PLC Hardware to be used by packaged equipment Vendor shall be as specified in the contract bid specifications. As a minimum, the processor used to interface to the Owner's SCADA system shall support the Schneider Electric Unity Pro programming software.
- B. Vendor shall use latest version of Schneider Electric Unity Pro programming software, unless otherwise directed by Owner.

##### **4.02 PROGRAM ORGANIZATION AND STRUCTURE**

- A. The overall program shall be broken down into meaningful sections of code related to the operations of the equipment. As a minimum, include the following program sections:
  - 1. Communications - All registers that are being written to or being read from the Vendor's package system PLC from the Owner's SCADA equipment shall be grouped into one section of the program. Register addresses used for interfacing to Owner's SCADA system shall be placed in a contiguous block of registers to facilitate read and write operations
  - 2. Section Control - (if code includes variables to enable/disable sections of code).
  - 3. Process Control - If the process is complex and/or the section is very large, this section should be further broken down into permissive section(s), alarming section(s) and control section(s).
  - 4. Input/Output (I/O) Processing – This section includes data manipulation of physical inputs and outputs such as analog scaling, totalizing, etc.
  - 5. PLC Time Synchronization and Heartbeat – This section shows the registers that are to be used to synchronize the PLC's clock with the Owner's SCADA system and to determine whether the Vendor's PLC logic is executing (heartbeat) to be monitored by the Owner's SCADA system.
- B. Vendor is to follow the Owner's software tagging convention for all tags being read from or written into by the Owner's SCADA system. If the Vendor elects to use their own software tagging convention in their programs that control the equipment within their own package system, then the PLC(s) that is used to interface with the Owner's SCADA system needs to include a set of registers that will be labeled with the Owner's software tagging convention and be "mapped" to the corresponding set of registers that are used by the Vendor's software program. The mapping of these registers is to be clearly labeled in the program and indicated on the Field I/O spreadsheet to be provided at the end of the job.
- C. All program sections are to be clearly labeled with text that describes what the section of code does. As a minimum, include the key wording for each section as described above.

- D. Provide comment lines within the sections of code to describe what the various parts of the section do, especially for those areas where the function is performing is not evident or is complex to follow.
- E. All software tags in the program are to follow a structured naming convention and be clearly labeled with meaningful text descriptions to make it easy to understand what the tag represents and what function it is performing in the program.
- F. Ensure that none of the programs developed have security controls enabled, i.e. password protection on DFB's, restrictions on uploading or editing program, etc.

#### **4.03 PROGRAM DETAILS**

- A. Vendor is to use IEC programming languages supported by Unity Pro, and in general adopt the following guidelines.
  - 1. Use Derived Function Blocks (DFB) language as much as practical to standardize on process control functions.
  - 2. Use Structured Text (ST) language for Calculations and I/O Mapping routines.
  - 3. Use IEC Ladder Logic (LL) and Function Blocks (FB) for control logic and to include in DFB's.
- B. Standardize the program sections and program elements (DFB, ST, etc.) as much as possible into modular and/or functional pieces of code for repetitive and often use sections of code to simplify the program and minimize its size.
- C. Vendor is to set up a Custom Library for standard program elements like DFB's and FB's.
- D. Use Topological (Unity Pro) Addressing on M340 PLCs for registers associated with physical I/O, i.e. %I1.3.2 and %Q1.4.3, instead of State Ram addressing (%M) since State Ram addressing convention does not reference the physical I/O location, but topological addressing does.
- E. Use eBool variables if there may be a reason to keep track of previous values (history) or there is a need to look at a leading or falling edge in the signal.
- F. Avoid using IEC BMDI function blocks on any of the PLC programs since Unity Pro is not able to search for registers contained within the range of that block.
- G. Use IO Scanner for communication between PLC's where possible to facilitate the set-up and troubleshooting of registers that are being moved from one PLC to another.
- H. Code should be designed to avoid using force bits for the logic to execute properly. Inadvertent un-forcing of bits will cause the program to behave unexpectedly.
- I. Do not initialize %MW values during a cold start or a program download. Doing so can cause stored values such as run time to be over written. Ensure this option is unchecked in the programming software if the option is available.

#### **4.04 DOCUMENTATION AND DELIVERABLES**

- A. As part of their Operations and Maintenance Manual, Vendor is to include, but not be limited to the following:
  - 1. Control Narratives that include:
    - a. The various control modes of operation; i.e. remote automatic, remote manual, local automatic, local manual, maintenance mode, etc.
    - b. Identification of and description of all permissive and shutdown signals that are required to operate the equipment or that will shut the equipment down.
    - c. Identification of all set points and process variables that are Operator adjustable with a description of what they do and how they affect the operation of the equipment.
  - 2. Field I/O and Host Pack and Peer to Peer spreadsheets (example provided by Owner) to document the various software tags associated with the package equipment.
  - 3. Instrument Index spreadsheet showing all instrumentation on their package equipment and calibration information including, but not limited to; instrument tag name, input range, units, control loop description, scaling, trip set points, etc.
- B. Vendor is to provide a copy of all program files installed in the production system and source files of all documentation listed above.

**END OF APPENDIX A**



## SECTION 13390

### APPENDIX B – AW HOST PACK SPREADSHEETS

#### PART 5 AW HOST PACK SPREADSHEETS

##### 5.01 FIELD I/O LIST DESCRIPTIONS NOTES

###### A. General

1. The Field Input/Output (I/O) lists only inputs or output connected to process control equipment and devices, i.e. instrument, electrical equipment, etc.. It does not include logical inputs or outputs that are generated as part of the PLC/RTU program to do data manipulation, or data that is passed on to another controller or Host computer.
2. All inputs and outputs associated with a PLC/RTU, i.e. physical and logical points, are shown on the Host Pack list if they are being transmitted/received by a Host computer, or are shown in the Peer to Peer Data Communications List, if the values are being shared with another peer device.

###### B. Information required for each entry.

1. RACK NAME - The rack name as shown on the contract drawings. Note this name is for cross-reference only. The actual drop, and rack number used in the software configuration will be as specified in the DROP, and RACK column of the Field I/O List.
2. FIELD DEVICE TAG - The name of the end device, in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Host Pack table.
3. DESCRIPTION - The description of the signal. This description shall be used consistently throughout the application software.
4. CARD/MODULE TYPE - The Modicon model number located in the corresponding slot.
5. POINT TYPE - The point type indicates AI, AO, DI, or DO for analog input, analog output, discrete input, or discrete output, respectively.
6. DROP, RACK/BASE – The drop and rack number associated with the chassis. These fields define the required drop, rack assignment for the configuration of each chassis associated with the processor.
7. SLOT - This field defines the physical location of the module within a given chassis.
8. I/O POINT – This field defines the specific point on the module.
9. CARD/MODULE TERMINALS – Physical wiring termination points on the I/O card/module.
10. FIELD I/O ADDR. - The software register address where the I/O module places the data for the point. This field is used as a cross-reference to the Host Pack table.

11. BIT NO. - The bit within the register address where the I/O module places the data for the point, as required. This field is used as a cross-reference to the Host Pack table.
12. EGU LOW - The value of the signal at 4 mA in the specified engineering units. This information is only applicable to analog signals.
13. EGU HIGH - The value of the signal at 20 mA in the specified engineering units. This information is only applicable to analog signals.
14. EGU - The engineering units for the analog signal. This information is only applicable to analog signals.
15. SCALED IN PLC? – Defines whether or not the analog value is scaled in the PLC, or if scaling occurs at the top end. This information is only applicable to analog signals.
16. RAW LOW - The value of the signal at 4 mA in counts as written to the PLC register by the I/O module. This information is only applicable to analog signals.
17. RAW HIGH - The value of the signal at 20 mA in counts as written to the PLC register by the I/O module. This information is only applicable to analog signals.
18. SIGNAL TYPE – Electrical characteristics of the signal, i.e. 4-20 mA, 1-5 VDC, etc.
19. TERMINAL BLOCK - The name of the block of terminals where field wiring is terminated.
20. TERMINAL NO'S - The terminal numbers within the terminal block where the field wiring is terminated.
21. LOOP DIAG. – The number of the drawing where a loop drawing is shown for the signal loop. These could either be loop-specific drawings, or typical loop drawings.
22. P&ID No. – The number of the P&ID drawing where the I/O point is shown on the drawings.
23. NOTES - Miscellaneous notes to further describe the signal. This field contains information such as square root (SQRT) for analog inputs, analog alarm setpoints, shelf states for discrete inputs, etc.

## **5.02 HOST PACK FIELD DESCRIPTIONS NOTES**

### **A. General Information**

1. Physical Inputs and Outputs (I/O) refer to connections to instruments and/or device/equipment including: motor status contacts, valve position switches, pump start/stop commands, etc.
2. There are two different tagging standards for physical I/O points, depending on whether they are instruments or signals coming from or going to equipment/devices other than instruments.
3. Instrument tags follow the ISA standards and are somewhat different from the other physical I/O points, i.e. equipment and devices, in that those tags include not only an equipment code, like the instruments, but it also includes a Function Descriptor Code that is up to four characters long. Since a piece of equipment/device may have multiple I/O points connected to it (such as a

motor starter) the Function Descriptor Code ensures uniqueness and clarifies the function performed by the specific I/O.

4. Software TagNames assigned to a PLC/RTU program are identical to the physical I/O points, i.e. Instrument Tags and Equipment/Device Tags.
5. Software TagNames that are generated by a controller or a host computer that are not tied directly to a physical I/O point, follow the same convention as the equipment and instrument tags, except a suffix is added to the end of the physical tag to indicate the origination/destination of that software tag, i.e. whether the point is logically created in the PLC/RTU or Host program and where it is sending its information to.

B. Information required for each entry.

1. Host SCADA Configuration Information – the fields in this section relate to configuration of alarming and general point information for use in the SCADA Host database.
  - a. HOST NODE NAME(S) - The computer name of PMCS SCADA Servers which will be polling the PLC, including OIUs.
  - b. HOST TAGNAME - The tagname used in the PMCS host software to reference the input point.
  - c. DB TYPE - The database point type used in the OIU and PMCS database definition for the point. See Table 4-3 in the System Integration Design Guide for a list of available database point types.
  - d. HOST DESCRIPTION - A description of the signal. The description field is limited to 40 characters.
  - e. ACTIVE STATE (1) - The definition of the energized state for a discrete point.
  - f. INACTIVE STATE (0) - The definition of the de-energized state for a discrete point.
  - g. ALARM STATE – Defines if either the Active or Inactive states will be used to generate an alarm a discrete point.
  - h. LOLO ALARM - The setpoint for the low low alarm limit for an analog point.
  - i. LO ALARM - The setpoint for the low alarm limit for an analog point.
  - j. HI ALARM - The setpoint for the high alarm limit for an analog point.
  - k. HIHI ALARM - The setpoint for the high high alarm limit for an analog point.
  - l. ALARM PRIORITY - The alarm priority. The alarm priority shall be defined as L, M, or H for low priority alarm, medium priority alarm, or high priority alarm, respectively. If the point does not require alarming, then this field shall be blank for the point. If multiple analog alarm setpoints are defined, alarm priorities shall be indicated for each alarm type.
2. PLC Host Read/Write Area – the fields in this section define the interface between the host database and the PLC/RTU.
  - a. HOST I/O ADDR - The register address in the PLC which the host will read to get the current value of the point.
  - b. HOST BIT NO - The bit within the register address in the PLC which the host will read to get the current value of the point.

- c. HOST PLC DATA TYPE - The data type of the signal in the PLC register. This defines how the PMCS interprets the data in the PLC register(s). Options for this field are based on the data types used in the PLC/RTU.
  - d. PLC SOFTWARE TAGNAME - The name of the register(s) that the PMCS host will read to current value of the point, as defined in the PLC/RTU software.
- 3. PLC Intermediate Area – the fields in this section identify any intermediate registers used in the PLC/RTU to perform calculations or process the input signals from the I/O module.
  - a. INT I/O ADDR - The register address in the PLC where the intermediate data value is stored.
  - b. INT BIT NO - The bit within the register address in the PLC where the intermediate data value is stored.
  - c. INT DATA TYPE - The data type of the signal in the intermediate PLC register. Options for this field are based on the data types used in the PLC/RTU.
  - d. PLC SOFTWARE TAGNAME - The name of the register(s) in the PLC where the intermediate data value is stored, as defined in the PLC/RTU software.
- 4. Field Interface Area – the fields in this section identify information about the field devices and register locations written to by the I/O modules.
  - a. PEER DEVICE – Indicates whether or not the point is transmitted from another PLC, as opposed to being acquired from local I/O.
  - b. FIELD DEVICE TAG - The name of the end device, in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table.
  - c. POINT TYPE - The point type indicates AI, AO, DI, or DO for analog input, analog output, discrete input, or discrete output, respectively.
  - d. FIELD I/O ADDR. - The software register address where the I/O module places the data for the point. This field is used as a cross-reference to the Field I/O List table.
  - e. FIELD BIT NO. - The bit within the register address where the I/O module places the data for the point, as required. This field is used as a cross-reference to the Field I/O List table.
- 5. Other fields
  - a. PLC/RTU EQUIPMENT TAG - The name of the PLC or RTU device, in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table.
  - b. NOTES – Miscellaneous notes specific to the database point.

### **5.03 PEER TO PEER DATA COMMUNICATIONS DESCRIPTIONS NOTES**

#### **A. General**

- 1. The Peer to Peer Data Communications list is intended to only show data (inputs or outputs) that is shared between two peer devices such as PLC/RTU controllers. The list does not include any other physical I/O points connected to

- the associated PLC/RTU or data points that are transmitted to or received from a Host computer.
2. For physical I/O points connected to a specific PLC/RTU, refer to the Field Input/Output (I/O) list.
  3. For data points that are associated with a particular PLC/RTU that are transmitted to or received from a Host computer, please refer to the Host Pack list.
  4. Information required for each entry.
    - a. PLC SOFTWARE TAGNAME - The name of the register(s) that the PMCS host will read to current value of the point, as defined in the PLC/RTU software.
    - b. DESCRIPTION - A description of the signal. The description field is limited to 40 characters.
    - c. HOST PLC DATA TYPE - The data type of the signal in the PLC register. This defines how the PMCS interprets the data in the PLC register(s). Options for this field are based on the data types used in the PLC/RTU.
    - d. ORIGINATION EQUIPMENT TAG - The name of the PLC or RTU device where the point data is coming from (source of the data), in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
    - e. ORIGINATION I/O ADDR - The register address in the source PLC which the destination peer device will read to get the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
    - f. ORIG BIT NO - The bit within the register address in the source PLC which the destination peer device will read to get the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
    - g. DESTINATION EQUIPMENT TAG - The name of the PLC or RTU device where the point data is being written to (consumer of the data), in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
    - h. DESTINATION I/O ADDR - The register address in the consumer PLC which the source peer device will write to provide the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
    - i. DEST BIT NO - The bit within the register address in the consumer PLC which the source peer device will write to provide the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
    - j. HOST INTERFACE? – Indicates whether the destination device passes the data to the PMCS host, or whether the data will be passed along to another peer device.

- k. BLOCK MOVE TYPE – Indicates the function block or other method used to facilitate the transfer of peer data.
- l. BLOCK MOVE DEVICE – The name of the PLC/RTU whose program includes the block move command. The Origination device can write the data to the Destination device, or the Destination device could read the data from the Origination device.
- m. NETWORK PROTOCOL – The protocol used to transport the peer data.
- n. NOTES – Miscellaneous notes specific to the database point.

**FACILITY:**  
**HOST/HMI NAME**

5/28/2021  
Harutunian Engineering, Inc. TBPE Firm F-2408







**FACILITY:**

**PLC/RTU EQUIPMENT TAG: \***

**END OF APPENDIX B**

## SECTION 13390

### APPENDIX C – AW Software Tagging Criteria

For signals associated with a stand-alone instrument:

PPPPPP\_TTTTTT\_IIII\_QQ

Where,

- PPPPPP = Process Identifier (abbreviation for process fluid shown on P&IDs)
- TTTTTT = Function Descriptor (see Austin Water Software Tag Function Descriptors table)
- IIII = Unique Identifier (Loop numbers for instrument - limited to 4 characters)
- QQ = Qualifier (see Table 3-4, AW Primary Qualifier Codes)

For signals associated with a piece of equipment:

PPPPPP\_TTTTTT\_IIII\_QQ

Where,

- PPPPPP = Equipment Code (as will be entered in INFOR)
- TTTTTT = Function Descriptor (see Austin Water Software Tag Function Descriptors table)
- IIII = Unique Identifier (Equipment ID - limited to 4 characters)
- QQ = Qualifier (see Table 3-4, AW Primary Qualifier Codes)

#### Function Descriptor Codes

The function descriptor code is a four character code used to indicate the specific equipment data being represented by the software point. Examples of equipment data include motor status, motor fault, motor start/stop commands, etc. The following tables list the function descriptor code available for use.

Austin Water SCADA  
Tag Function Descriptor Standards

11/12/2013

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
AAH	Input	High Analyzer Concentration Alarm
AAL	Input	Low Analyzer Concentration Alarm
ACNC	Input	Active Concentration
ACTP	Input	Analog Cell Temperature
ACTV	Input	Active or in Progress
AFB1	Input	Auto Flow Pace - Flow Meter 1
AFB2	Input	Auto Flow Pace - Flow Meter 2
AFBD	Input	Auto Flow Pace - Calculated Data
AFBF	Input	Auto Flow Pace - Flow Meter
ALCR	Input	Critical Alarm
ALMN	Input	Maintenance Alarm
ALARM	Input	Alarm
ALRT	Input	Alert
ALTSW	Input	Alternate Switch
AMPH	Input	High Amp
AMPL	Input	Low Amp
AMPS	Input	Amps
ASIL	Input	Motor Auto Stop Interlock
ATPT	Input	Attempt (used for substation transfer attempt Counter)
AUTO	Input	Auto
AVG	Input	Average Selected
BATA	Input	PLC Controller Battery A Alarm
BATB	Input	PLC Controller Battery B Alarm
BATGEN	Input	Generator Battery Alarm
BFTC	Input	Breaker Fail to Close
BFTO	Input	Breaker Fail to Open
BKAC	Input	Breaker Ok to Close
BKRC	Input	Breaker Closed
BKRO	Input	Breaker Open
BKWF	Input	Filter Backwash Sequence Failure Alarm
BKWH	Input	Strainer in Backwash
BKWM	Input	Filter in Manual Backwash Mode
BLCB	Input	Level Control Band
BYP	Input	Bypass (e.g., UPS)
CAPC	Input	Metering Pump Capacity
CALFLW	Input	Calculated Flow
CALLFL	Input	Call Fail
CBLA	Input	Global Communications Cable A Fault
CBLB	Input	Global Communications Cable B Fault
CFLA	Input	Communications Fail Channel A

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

<b>Code</b>	<b>Type</b>	<b>Description</b>
CFLB	Input	Communications Fail Channel B
CHCK	Input	Check Valve Fail to Open
CLFH	Input	Hypochlorite Generator High Cell Flow
CLFL	Input	Hypochlorite Generator Low Cell Flow
CLOCK	Input	PLC Clock
CLOS	Input	Close
CLRUN	Input	Call to Run
CLSD	Input	Limit Switch Closed
CLTP	Input	Hypochlorite Generator Cell Temperature
CMERAV	Input	Total Communication Errors Average
CMERLG	Input	Total Communication Good
CMERT	Input	Total Communication Errors
CMFL	Input	Communication Fail
CMPLD	Input	Last Poll Period
CMTRLT	Input	Total Comm Transmissions
CNRA	Input	Polymer Mixing Unit Centrifuge Not Run Alarm
COMERR	Input	Communication Error
CPRM	Input	Close Permissive
CPUSTA	Input	CPU Status Diagnostic
CRSW	Input	Current Switch
CRTM	Input	Time Until Next Cleaning
CYAC	Input	Cycle Timer Accumulated Time
CYCR	Input	Cycle Freq Timer
CYRM	Input	Remaining Time Until Next Cycle
CYSP	Input	Cycle Stop
CYST	Input	Cycle Start
DATAQL	Input	Data Quality
DAY	Input	PLC Clock Day of Month
DENS	Input	Chemical Density
DRAC	Input	Duration Timer Acc Val
DRRM	Input	Time Remaining Until Duration Ends
DRPS	Input	Duration Timer Reset
DSBL	Input	Disable
DSCH	Input	Discharge Rate
DSTC	Input	Discharge to Chlorine (App Point Chlorine Injection Vaults 1-4)
DSTF	Input	Discharge to Filters (App Point is Filtered Water Injection Vault)
DSTN	Input	Discharge to None (Application Point is Not Selected)
DSWF	Input	Lime Slaker Discharge Weight Fault
EMRG	Input	Emergency (e.g., ATS in Emergency Power)

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
ENAB	Input	Enable Control Status
ENAX	Input	Enable State X
ENBL	Input	Enabled (e.g., Auto Transfer at SUB enabled)
ESL	Input	Undervoltage Alarm
ESTP	Input	Emergency Stop
ET	Input	Voltage
EUH	Input	High Engineering Units
EUL	Input	Low Engineering Units
EXRNTM	Input	Extensive Run Time
EYEW	Input	Eyewash Station No. 1 Flow Switch High
FAIL	Input	Failure (e.g., PLC Fail)
FAUL	Input	Fault (e.g., Lime Slurry Aging Tank Mixer Fault)
FAUT	Input	Motor Flow Pacing Auto Control Status
FDFA	Input	Flow Rate Difference Alarm (e.g., delta between calculated and actual flow)
FIT	Input	Flow Indicating Transmitter / Signal
FILFMX	Input	Lifetime Max Flow
FITOMX	Input	Today's Max Flow
FIYEMC	Input	Yesterday's Max Flow
FLOW	Input	Flow/Flow Mode
FLWO	Input	Flow Pacing Selection Reset
FLWC	Input	Hypochlorite Generator Cell Flow
FLWX	Input	Flow X Selected for Flow Pacing
FQAC	Input	Frequency Timer Accumulated Value
FQICUR	Input	Current Day Flow Total
FQILF	Input	Lifetime Flow Total
FQIPRE	Input	Previous Day Flow Total
FQITOT	Input	Calculated Flow Total
FQPS	Input	Frequency Timer Preset
FRDH	Input	Flow rate difference high (when instrument flow compared to calculated flow)
FRFS	Input	Fail to reach flow setpoint
FRPS	Input	Fail to reach position setpoint
FSL	Input	Low Flow Switch
FSP_ACC	Input	Accumulated Fail to Stop Time
FSRT	Input	Fail to Start
FSTP	Input	Fail to Stop
FTAC	Input	Fail Timer Accumulated Value
FTC	Input	Fail to Close
FTO	Input	Fail to Open
FTPS	Input	Fail Timer Preset
FUSB	Input	Fuse Blown

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
FXRM	Input	Fixed Rate Mode (vs. Level Rate Mode)
GRND	Input	Ground Fault Alarm
HDLS	Input	Headloss (e.g., filters)
HDWR	Input	Hardware
HLTH	Input	PLC Power & Scan Health Status
HOLD	Input	Hold Calculation Command
HOPP	Input	Hopper
HOUR	Input	PLC Clock Hour (Military) from Host
HTBT	Input	Heartbeat (Used for communication check)
HRUN	Input	High Speed Running Status
HSTR	Input	Motor High Speed Start Command
HVR	Input	Voltage High (e.g., battery)
ILCK	Input	Interlock
INIT	Input	Total Run-time Alarm/Hours Reset
ISRV	Input	In Service Command
KILK	Input	Key Interlock
KQAH	Input	Motor Service Alarm
KQI	Input	Runtime
KQI1	Input	Service Runtime
KQI2	Input	Lifetime Runtime
KQI3	Input	Runtime Since Start
KQILF	Input	Lifetime Runtime
KQIMN	Input	Monthly Runtime
KQIMP	Input	Previous Monthly Runtime
KQITO	Input	Today's Runtime
KQIYE	Input	Yesterday's Runtime
KWHMG	Input	KWH / MG Today
KWHMG	Input	KWH / MG Yesterday
LAUT	Input	Motor Local Auto Control Status
LAGPMP	Input	Lag Pump Run
LCRM	Input	Equipment in Local or Remote
LDRA	Input	Level Decline Rate Alarm
LDRD	Input	Level Decline Rate Difference
LEAD	Input	Equipment is Load
LEAK	Input	Leak indication (.g., high gas concentration)
LEVEL	Input	Level
LGPSTS	Input	Lag Pump Starts Today
LI2DMN	Input	Minimum Level from 2 Days ago
LI2MDX	Input	Maximum Level from 2 Days ago

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
LIT	Input	Level Indicating Transmitter
LITOMN	Input	Today's Level Minimum
LITOMX	Input	Today's Level Maximum
LIWF	Input	Lime Slaker Lime Inlet Weight Fault
LIYEMN	Input	Yesterday's Level Minimum
LIYEMX	Input	Yesterday's Level Maximum
LMAN	Input	Motor Local Manual Control Status
LMWT	Input	Lime Weight
LOAL	Input	Lockout Alarm
LOCK	Input	Lockout
LOCL	Input	Local
LOGC	Input	Controller A/B Logic Mismatch
LRUN	Input	Low Speed Running Status
LSHH	Input	Level Switch Hi-Hi
LSH	Input	Level Switch Hi
LSLL	Input	Level Switch Lo-Lo
LSL	Input	Level Switch Lo
LSTR	Input	Motor Low Speed Start Command
LVHH	Input	Level Hi-Hi
LVLB	Input	Level of Brine
LVLL	Input	Level Lo-Lo
LVLN	Input	Level of Salt
LVLQAI	Input	Level Data Quality
LVLX	Input	Level X Selected
LVR	Input	Voltage Low (e.g., battery)
LVRM	Input	Level Rate Mode (vs. Fixed Rate Mode)
LY	Input	Bubbler / Level Transmitter Fail
MAN	Input	Manual
MDBBD	Input	Modbus Baud
MDBDL	Input	Modbus Data Length
MDBDP	Input	Modbus Data Parity
MDBRT	Input	Modbus Retries
MDBSB	Input	Modbus Stop Bit
MDBTO	Input	Modbus Timeout
MDFT	Input	Frequency Timer Mode
MDSP	Input	Sludge Pump Mode (UFC Residual)
MIN	Input	Clock Minute
MLR	Input	Motor Lockout Relay
MNFL	Input	Manual Flow
MNPS	Input	Manual Position Mode



Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
MNSP	Input	Manual Speed SP Mode
MNTN	Input	Maintenance Mode
MODALN	Input	Module (IO) Alarm
MODBD	Input	Modem Baud
MODDL	Input	Modem Data Length
MODDP	Input	Modem Data Parity
MODE	Input	Status or Mode
MODSB	Input	Modem Stop Bit
MONTH	Input	Clock Month
MPR	Input	Motor Protector Relay Alarm
MSIL	Input	Motor Manual Stop Interlock
NSH	Input	Hi Torque Alarm
NCR	Input	No Charge (e.g., battery)
NDST	Input	Output to No Destination (e.g., metering pumps)
NGR	Input	Negative Ground (e.g., battery)
NLRM	Input	None in Level Rate Mode Alarm (UFCs)
NMSTOP	Input	Normal Stop Cycle
NORM	Input	Normal (e.g., ATS Normal Power)
NOTAVL	Input	Not Available
NOTK	Input	Standby Controller Not On LAN
NSH	Input	Hi Torque Switch
NSHH	Input	Hi-Hi Torque Alarm
NSHHH	Input	Drive Motor Cut Out Torque Alarm
NUMBR	Input	Telephone Number
OAAF	Input	Operator Adjustable Adjustment Factor (e.g., metering pump dose calculations)
OFAC	Input	Cycle Timer Off Accumulated Valve
OFF	Input	Off Status
OFFX	Input	Disable State X Command
OFLN	Input	Offline
OFPS	Input	Cycle Timer Off Preset
ON	Input	On / Running
ONAC	Input	Cycle Timer On Accumulated Value
OPEN	Input	Open Status
ONPS	Input	Cycle Timer On Preset
OPRM	Input	Open Permissive
OORAIX	Input	Out of Range for Analog Input Channel X
OORAOX	Input	Out of Range for Analog Output Channel X
OSRV	Input	Out of Service Command
OVLD	Input	Overload

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
PBSP	Input	Push Button Stop (e.g., LSPS)
PBST	Input	Push Button Start (e.g., LSPS)
PDAH	Input	High Differential Alarm
PFLD	Input	Power Factor Lead
PFLG	Input	Power Factor Lag
PFOL	Input	Power Factor Capacitor Overload
PGR	Input	Positive Ground Detect (e.g., battery charger)
PICK	Input	Pickup Coil
PING	Input	PING (e.g., PLC PING status)
PIT	Input	Pressure Indicating Transmitter
PMPX	Input	Pump X Selected
PNLF	Input	Front Panel Open
POLLCD	Input	Poll Command
POLLST	Input	Last Poll Status
PRTY	Input	Chemical Purity
PRMA	Input	Controller A is Primary
PRMB	Input	Controller B is Primary
PROC	Input	Motor Process Permissive
PSAC	Input	Parallel Source Active (e.g., SUB1)
PSAL	Input	Parallel Source Alarm (e.g., SUB1)
PSH	Input	Pressure Switch High
PSL	Input	Pressure Switch Low
PSTR	Input	Motor Pending Startup Status
PWRA	Input	Power Fail A
PWRB	Input	Power Fail B
QFEF	Input	Filters Effluent Flow Dosage Point
QRWF	Input	Raw Water Flow to Clarifiers Dosage Point
RAIXHD	Input	RTU Analog Point 'X' Health Diagnostic
RALL	Input	Remote Auto Lead-Lag Control Mode
RALM	Input	Resettable Alarm
RAPR	Input	Remote Auto Percentage mode
RAUT	Input	Motor Remoter Auto Control Status
RDY	Input	Equipment Ready Status
REFVLP	Input	Reference Voltage Positive
REFVLN	Input	Reference Voltage Negative
RIOP	Input	Global Communications RIO Health Fault
RKXFLT	Input	Rack Fault for Rack No. 'X'
RMDXHD	Input	RTU Module 'X' Health Diagnostic Status
RMOT	Input	Remote
RSET	Input	Alarm Reset

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
RSME	Input	Resume Calculation Command
RTHI	Input	Runtime Hi Alarm
RTMH	Input	Rectifier High Temp Hi
RTODDT	Input	RTU Time Of Day – Date
RTODDY	Input	RTU Time Of Day – Day
RTODHR	Input	RTU Time Of Day – Hour
RTODMN	Input	RTU Time Of Day – Minute
RTODSC	Input	RTU Time Of Day – Second
RTODYR	Input	RTU Time Of Day – Year
RTS	Input	Return to Service
RUNA	Input	Running Alarm
RUNC	Input	Close Contactor is Energized (e.g., electric actuator)
RUNN	Input	Motor Running
RUNO	Input	Open Contactor is Energized (e.g., electric actuator)
RUNTIME	Input	Service Time Preset/Reset Value
RVSF	Input	RVSS (Reduced Voltage Solid-state Starter) Fault
RXXSTA	Input	Rack 0 Slot XX Status (OK)
S908	Input	Global Communications Health Fault
SAFE	Input	Motor Safety Permissive (Future)
SALM	Input	Alarm Exists
SAUT	Input	Motor Speed Auto Control Status
SBYA	Input	Controller A is Standby
SBYB	Input	Controller B is Standby
SCAN	Input	PLC Scan Time
SCLB	Input	Scale Buildup (Lime Slaker)
SCLH	Input	Scale Buildup High Alarm (Lime Slaker)
SEC	Input	Clock Seconds
SELX	Input	State X Selected
SHDN	Input	Shutdown Alarm
SHOL	Input	Space Heater Overload
SILK	Input	Motor Stop Interlock
SLTL	Input	Salt Tank Low
SOFF	Input	Selector Switch in OFF
SON	Input	Selector Switch in ON
SPRM	Input	Start Permissive
SRAM	Input	PLC State RAM
ST	Input	Speed Feedback
STBY	Input	Stand-by Status
STDN	Input	Shutdown

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
STEP	Input	Sequence Step
STLF	Input	Lifetime Starts
STRK	Input	Stroke
STRT	Input	Motor Start
STOP	Input	Motor / Valve Stop
STSEXD	Input	Starts Exceeded
STSEXB	Input	Starts Exceeded Bypassed
STTO	Input	Today's Starts
STYE	Input	Yesterday's Starts
SUCC	Input	Success
SURG	Input	Surge Alarm
SWAP	Input	PLC Swap Over Command
SYNC	Input	Sync Check Relay
TALM	Input	Temperature Alarm
TDAC	Input	Time Delay Off Accumulated Value
TEMP	Input	Temperature
TIMSTP	Input	Time Stamp
TGON	Input	Tagout On
TOC	Input	Truck Operated Contact (Vacuum Circuit Breaker)
TODFUL	Input	Time of Day Events Full
TODNUM	Input	Time of Day Events Number
TODSYN	Input	Synch RTU Clock to FEP
TOKN	Input	Token Rotation Time in secs
TOTL	Input	Total
TRBL	Input	Trouble (Malfunction) Alarm
TSH	Input	High Temperature Switch
TSL	Input	Low Temperature Switch
UFRV	Input	Unit Filter Run Volume
UPSB	Input	UPS Low Battery
UPSF	Input	UPS Fail
VFDA	Input	VFD Alarm
VFDT	Input	VFD Temperature Alarm
VFTC	Input	Valve Fail to close
VFTO	Input	Valve Fail to open
VSH	Input	High Vibration
VSHH	Input	High High Vibration
VSL	Input	Low Vibration
WALM	Input	Weight Alarm

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
WARN	Input	Warning
WIWF	Input	Water Inlet Weight Fault (Lime Slaker)
WSFL	Input	Weight Sensor Fault (e.g., Lime Slurry Aging Tank)
WY	Input	Weight Tared
XA	Input	Surge Suppressor Alarm
XFER	Input	Transfer Relay (e.g., initiates SUB1 transfer algorithm)
XHK	Input	Dosage Set point
XHLD	Input	Hold Calculation Status
XMTECD	Input	Transmit Error Code
XMTEND	Input	Transmit Error Node
XS	Input	General Switch Input
XSRV	Input	Filter In Service Status
XTND	Input	Filter Extend Backwash Notification
XTON	Input	Filter Extend Backwash On Status
XTOP	Input	Stop
XQI	Input	Current Day Start Count
XYSN	Input	Module Health Drop X Rack Y Slot N
YEAR	Input	Clock Year
ZA	Input	Valve Fail Alarm
ZDO	Input	Zero Dropout Value
ZS	Input	General Switch Input
ZSC	Input	Position switch close
ZSO	Input	Position switch open
ZT	Input	Position Feedback
AHK	Output	Remote Analyzer Setpoint
CLOS	Output	Equipment Close Coil
CYPS	Output	Cycle Preset Time Setpoint
DRPS	Output	Duration Preset Time Setpoint
FHK	Output	Flow Setpoint
FHKx	Output	Flow Setpoint, where x is a unique digit (when multiple setpoints used)
FIC	Output	Flow Controller Output
HSTR	Output	High Speed Start Coil
HXTP	Output	High Speed Stop Coil
KQC	Output	Runtime Reset Value
LHK	Output	Level Setpoint
LHKx	Output	Level Setpoint, where x is a unique digit (e.g., used in multi-level setpoints for tanks)

Austin Water SCADA  
Tag Function Descriptor Standards

**Austin Water Software Tag Function Descriptors**

Code	Type	Description
LSTR	Output	Low Speed Start Coil
LXTP	Output	Low Speed Stop Coil
MNRTSP	Output	Minimum Pump Runtime Setpoints
OFFSP	Output	Off Setpoint
ONFR	Output	Online Fixed Rate Mode Command
ONLR	Output	Online Level Rate Mode Command
ONSP	Output	On Setpoint
OPEN	Output	Equipment Open Coil
RNTRST	Output	Runtime Reset
RSET	Output	Reset Command
RST1	Output	Reset Service Runtime Command
RST2	Output	Reset Life Runtime Command
RVAL	Output	Equipment Runtime Preset Value
SHK	Output	Speed Setpoint
SHKx	Output	Speed Setpoint, where x is a unique digit (when multiple setpoints used)
SPBD	Output	Stop Blowdown Command
SRINSP	Output	Service Alarm Interval Setpoint
STBD	Output	Start Blowdown Command
STOP	Output	Stop Command
STRT	Output	Start Command
TGDT	Output	Tagout Date Setpoint
TGRN	Output	Tagout Reason Setpoint
TGRS	Output	Tagout Reset Command
TGST	Output	Tagout Set Command
TGTM	Output	Tagout Time Setpoint
TGUS	Output	Tagout User Setpoint
XFER	Output	Transfer Coil
XHK	Output	Dosage Setpoint
XHKx	Output	Dosage Setpoint, where x is a unique digit (when multiple setpoints used)
XRUN	Output	Motor Run / Stop Coil
XTOP	Output	Motor Stop Coil
ZHK	Output	Position Setpoint
ZHKx	Output	Position Setpoint, where x is a unique digit (when multiple setpoints used)
ZVC	Output	Valve Close Command
ZVO	Output	Valve Open Command
ZVC	Output	Valve Open / Close Coil

Austin Water SCADA  
Tag Function Descriptor Standards

**Table 3-4**  
**Primary Qualifier Codes**

<b>Qualifier Code</b>	<b>Description</b>
I	Field inputs to PLC.
O	Field outputs from PLC.
F	Filtered values/coils (used for existing software tag names only).
HI	Host inputs read from PLC.
HR	Host register read from/written to PLC.
M	Logic modified values/coils.
P	Peer-to-Peer points.
S	Scaled values.
DW	Host write to data source.
DR	Host read from data source.
PB	Primary Block.
CSB	Secondary Block.
LHI	Local Host (OIU) inputs read from PLC.
LHO	Local Host (OIU) outputs written to PLC.
LHR	Local Host (OIU) register read / wire to PLC

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## MECHANICAL IDENTIFICATION

## 1.01 SUMMARY

- ## 1.02 RELATED REQUIREMENTS

- ### 1.03 REFERENCES

**AMERICAN NATIONAL STANDARD INSTITUTE (ANSI)**

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

## 1.04 DEFINITIONS (NOT USED)

## 1.05 SYSTEM DESCRIPTION

- ## 1.06 SUBMITTALS

- ## MECHANICAL IDENTIFICATION

## **1.07 QUALITY ASSURANCE**

- A. Regulatory requirements:
  - 1. Comply with Texas Commission on Environmental Quality (TCEQ):
    - a. Chapter 217 – Design Criteria for Wastewater Systems
    - b. Chapter 290 - Public Drinking Water.
  - 2. Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

## **1.08 DELIVERY, STORAGE AND HANDLING**

- A. Delivery products to site in factory packed boxes or crates.
- B. Store inside. Protect from weather and damage until installed.

## **1.09 – 1.11 (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Manufacturer: Subject to compliance with the requirements of this Section, provide mechanical identification materials from one of the following manufacturers.
  - 1. Allen Systems, Inc.
  - 2. Brady (W.H.) Co.; Signmark Div.
  - 3. Industrial Safety Supply Co., Inc.
  - 4. Seton Name Plate Corp.

### **2.02 MATERIALS AND/OR EQUIPMENT**

- A. General: Provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category.
- B. Equipment Nameplates
  - 1. Material and fabrication:
    - a. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.
  - 2. Fasteners:
    - a. Number 4 or larger oval head stainless steel screws or drive pins.
  - 3. Text:
    - a. Manufacturer's name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.
- C. Painted Identification Materials:
  - 1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1¼" high letters for ductwork and not less than ¾" high letters for access door signs and similar operational instructions.
  - 2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.
  - 3. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ANSI A13.1 for colors.
- D. Plastic Pipe Markers:
  - 1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

2. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1.
  3. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on non-insulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.
  4. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
    - a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
    - b. Adhesive lap joint in pipe marker overlap.
    - c. Laminated or bonded application of pipe marker to pipe (or insulation).
    - d. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1½".
  5. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:
    - a. Laminated or bonded application of pipe marker to pipe (or insulation).
    - b. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1½" wide; full circle at both ends of pipe marker, tape lapped 3".
    - c. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.
  6. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length.
    - a. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic.
- E. Plastic Tape:
1. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.
  2. Width: Provide 1½" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6", 2½" wide tape for larger pipes.
  3. Color: Comply with ANSI A13.1, except where another color selection is indicated.
- F. Valve Tags:
1. Provide 2" diameter, 0.025" thick, polished stainless steel valve tags with 3/16" hole for mounting.
  2. Marking:
    - a. Scheduled Valves: Tags are to be stamped or engraved with the tag number listed in the valve schedule:
      - 1) First Line: Area code.
      - 2) Second Line: Equipment code.
      - 3) Third Line: Unit code.
      - 4) Lettering Height: 1/8".
    - b. Unscheduled Valves: Tags are to describe the service with a sequential number:
      - 1) First Line: Service - 1/4" high lettering.
      - 2) Second Line: Sequential number - 1/2" high lettering.
    - c. Fill tag engraving with black enamel.

3. Valve Tag Fasteners:
    - a. Stainless steel screws;
    - b. Stainless steel nuts and bolts;
    - c. Stainless steel wire (1/16") with swagged terminations;
    - d. No. 6 stainless steel beaded chain; or
    - e. No. 16 stainless steel jack chain.
  4. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic laminate access panel markers, with abbreviations, and numbers corresponding to concealed valve, unless otherwise required by code. Include 1/8" center hole to allow attachment.
- G. Valve Schedule Frames:
1. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.
- H. Engraved Plastic-Laminate Signs:
1. General: Provide engraving stock melamine plastic laminate, complying with ASTM D709, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
  2. Thickness: 1/16" for units up to 20 sq.in. or 8" length; 1/8" for larger units.
  3. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
- I. Plastic Equipment Markers:
1. General: Provide manufacturer's standard laminated plastic, color-coded equipment markers. Conform to the following color code.
    - a. Green: Cooling equipment and components.
    - b. Yellow: Heating equipment and components.
    - c. Yellow/Green: Combination cooling and heating equipment and components.
    - d. Brown: Energy reclamation equipment and components.
    - e. Blue: Equipment and components that do not meet any of the above criteria.
    - f. For hazardous equipment, use colors and designs recommended by ANSI A13.1.
  2. Nomenclature: Include the following, matching terminology on schedules as closely as possible.
    - a. Name and plan number.
    - b. Equipment service.
    - c. Design capacity.
    - d. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.
  3. Size: Provide approximate 2½" × 4" markers for control devices, dampers and valves; and 4½" × 6" for equipment.
- J. Lettering and Graphics:
1. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
    - a. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (e.g., Boiler No. 3, Air Supply No. 1H, Standpipe F12).

K. Special Items

1. In addition, special coating of following items will be required:

Item	Color
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

L. Underground Warning Tape

1. Material:

- a. Metallic detection tape; minimum 4 mil thick by 6 inches wide polyethylene film with wording, "Caution" with name of service followed by words, "Line Buried Below" repeated continuously along tape length, with alternate metallic and color strips.

## 2.03 EXTRA STOCK

A. Furnish minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

## PART 3 EXECUTION

### 3.01 GENERAL

- A. Install all labels and identification tags in accordance with the manufacturer's printed instructions. Appearance to be neat and uniform. Tags and/or labels to be readily visible from normal working locations.
- B. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

### 3.02 PREPARATION

- A. Prepare and coat surfaces as Specified in Contract documents.
- B. Prepare surface in accordance with product manufacturer's instructions.

### 3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

- A. Existing Identification Systems: In installations where existing piping identification systems have been established, continue to use the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the specified system. The objective is to fully identify all new equipment, piping, valves, and appurtenances to the level specified herein.
- B. Piping System Identification:
  1. General: Pipe identification to consist of 4 elements - 2 color-coded bands, a lettered label, and a flow arrow to indicate direction of flow in the pipe. Color bands to be painted directly upon the pipe or of the pressure-sensitive, adhesive-backed, vinyl cloth or plastic tape type. Labels to be preprinted on pressure-sensitive, adhesive-backed, vinyl cloth or plastic tape. Arrows to be die-cut of the same type of material as the labels. Arrange bands so that the lettered label and the directional arrow are placed between the 2 bands. Install pipe markers of

one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow.

- a. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2" beyond ends of lettering.
  - b. Letter sizes and colors for lettering, arrows, and background to conform to ANSI A13.1.
  - c. Plastic pipe markers, with application system as indicated under "Materials" in this Section. Install on pipe insulation segment where required for hot non-insulated pipes.
  - d. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.
2. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
- a. Near each valve and control device.
  - b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
  - c. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
  - d. At access doors, manholes and similar access points which permit view of concealed piping.
  - e. Near major equipment items and other points of origination and termination.
  - f. Piping to be identified at intervals of 20 feet, and at least one time in each room. Identify piping at a point approximately within 2 feet of all turns, ells, valves, and on the upstream side of all distribution fittings or branches. Sections of pipe that are too short to be identified with color bands, lettered labels, and directional arrows are to be tagged and identified similar to valves.
  - g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.
3. Sections of pipe that are too short to be identified with color bands, lettered labels, and arrows are to be identified with metal or plastic tags as specified herein.

C. Valve Identification:

1. General: Provide valve tag on every valve, cock and control device in each piping system; exclude valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
2. Valve tags are to be permanently attached to the valve as follows:
  - a. Valves 12-inches and Smaller: Attach tag to valve with SS beaded chain, SS jack chain, or SS wire.
  - b. Valves Larger than 12-inches: Attach tag to valve using SS screw(s) or SS nuts and bolts.
3. Mount valve schedule frames and schedules in rooms where indicated or, if not otherwise indicated, where directed by ENGINEER.
  - a. Where more than one major machine room is shown for project, install mounted valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

D. Equipment Identification:

1. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as

specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:

- a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
  - b. Meters, gages, thermometers and similar units.
  - c. Fuel-burning units including boilers, furnaces, heaters, stills and absorption units.
  - d. Pumps, compressors, chillers, condensers and similar motor-driven units.
  - e. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
  - f. Fans, blowers, primary balancing dampers and mixing boxes.
  - g. Packaged HVAC central-station or zone-type units.
  - h. Tanks and pressure vessels.
  - i. Strainers, filters, humidifiers, water treatment systems and similar equipment.
2. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at installer's option.
  3. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.
  4. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
    - a. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

### **3.04 – 3.05 (NOT USED)**

### **3.06 ADJUSTING**

- A. Relocate any mechanical identification device which has become visually blocked by work of other divisions.

### **3.07 CLEANING**

- A. Clean face of identification devices, and glass frames of valve charts.

### **3.08 - 3.10 (NOT USED)**

### **3.11 MEASUREMENT AND PARMENT**

No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**

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## **SECTION 15172**

### **ELECTRICAL MOTOR, HIGH EFFICIENCY, HORIZONTAL INDUCTION, 300 HP & SMALLER**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Furnish and install mill and chemical horizontal high efficiency, squirrel cage induction motor; Design B, normal starting current and torque; furnish as integral part of rotating equipment unit. Motor to be most premium efficient type available from motor manufacturer.

##### **1.02 RELATED REQUIREMENTS**

- A. PLANS, this and other TECHNICAL SPECIFICATION Sections, and equipment manufacturer requirements define voltage, speed, special features, driven equipment requirements, and special submittal data.
- B. Related work as called for on PLANS or specified in this or other TECHNICAL SPECIFICATION Sections.

##### **1.03 REFERENCES**

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.

#### **AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)**

ABMA 9                      Load Ratings and Fatigue Life for Ball Bearings

#### **INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)**

IEEE 112                      Standard Test Procedures for Polyphase Induction Motors and Generators

IEEE 841                      Standard for Petroleum and Chemical Industry – Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 500 HP

#### **NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)**

NEMA MG 1                      Motors and Generators

##### **1.04 - 1.05 (NOT USED)**

##### **1.06 SUBMITTALS**

- A. Furnish the following in accordance with Specifications Section 01300, "Submittals" and Section 01730, "Operation and Maintenance Data".
  - 1. Shop Drawings. In addition to the items specified in Section 01300, "Submittals", furnish the following information:

- a. Full nameplate information in accordance with NEMA Standard MG-1; full torque; and efficiency and power factor data at full load,  $\frac{3}{4}$  load, and  $\frac{1}{2}$  load.
  - b. When power factor correction capacitor is provided in motor circuit, all nameplate information affected by addition of capacitor to be corrected and submitted in addition to information described herein.
  - c. Speed torque characteristics, safe stall time, and thermal damage curves.
  - d. Space heater voltage and wattage.
  - e. Bearing size and calculation.
  - f. Data to be included on nameplate.
  - g. Dimensioned outlined drawings.
  - h. Net weight of assembled motor and net weight of heaviest part to be handled during field assembly or disassembly.
  - i. When power factor correction capacitors are required, include to-scale arrangement drawings showing configurations of capacitor inside the high voltage termination box.
  - j. Full load amperes (FLA), no load amperes, and locked rotor amperes (LRA) at rated voltage.
- 2. Operation and Maintenance Manuals: Furnish in accordance with Contract Documents. Manuals to contain speed-torque, safe stall time (thermal damage) and acceleration curves also.
  - 3. Reports: Submit certified tests for review by the ENGINEER prior to shipment.

#### **1.07 QUALITY ASSURANCE**

- A. Latest edition of NEMA Standard MG-1 and applicable provisions of IEEE, ANSI, NEC, OSHA, and UL.
- B. Furnish identical motors and accessories from a single motor manufacturer for multiple units of the same equipment.
- C. Sole Source Responsibility: Utilize a single supplier to provide the drive motor, the motor mounts and any accessories.

#### **1.08 DELIVERY, STORAGE AND HANDLING**

- A. Protect from weather and insects with polyethylene wrapper; furnish and energize space heaters to preclude moisture.

#### **1.09 - 1.11 (NOT USED)**

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURER(S)**

- A. Teco-Westinghouse;
- B. General Electric;
- C. U.S. Motor-Corro Duty Energy Efficient;
- D. Reliance-High Performance Type XE;

#### **2.02 MATERIALS AND/OR EQUIPMENT**

- A. Performance: Unless otherwise noted in the driven equipment specification sections, the following items apply as a default standard:
1. Brake Horsepower: As designated in driven equipment specifications. Brake horsepower of the driven equipment is not to exceed the motor nameplate horsepower rating, excluding any service factor.
  2. Power Factor (as required by applicable Specification Section and/or as shown on PLANS):
    - a. Minimum full load power factor (uncorrected): 85 percent.
    - b. When noted on PLANS, corrected minimum full load power factor: 95 percent.
  3. Minimum Efficiency at Rating: Motors to be of a premium energy-efficient design per NEMA MG-1, 2006, Tables 12-12 and 12-13.
  4. Maximum Locked Rotor Indicating Code Letter: G for motors sized 15 horsepower and larger.
- B. Application: Unless otherwise designated in the Driven Equipment Specification, furnish the following:
1. Enclosure: TEFC.
  2. Service Factor: 1.15.
  3. Mounting: As required by the driven equipment.
  4. 120-volt space heaters.
  5. Starting: Across the line, full voltage starting except motors larger than 50 HP to be suitable for reduced voltage starting using reduced voltage solid state starters.
  6. Duty Rating: Continuous.
  7. Frequency: 60 Hz.
  8. Lifting: Lug.
- C. Construction and Materials:
1. Frame: Cast iron, size per NEMA designations.
  2. End Shields/Brackets: Cast iron.
  3. Drain/Breather: Stainless steel "T" drains in end brackets.
  4. Fan Shroud: Cast iron.
  5. Motor Terminal Box: Oversize, cast iron, diagonally split, rotatable, threaded hubs for conduit attachment. Sized per NEMA MG 1, Section 1, Paragraph 4.19. Terminal box to be gasketed to frame and furnished with grounding lug.
  6. Cooling Fan: Aluminum or polypropylene.
  7. Wiring and Insulation: Copper with nonhygroscopic Class F insulation, Class B temperature rise not to exceed insulation temperature rating when operating at service factor rating in 40°C ambient according to NEMA MG 1-12.42. Include extra dips and bakes for high humidity.
  8. Rotor: Precision cast aluminum conductor bars, statically and dynamically balanced.
  9. Bearings: Ball bearings, B<sub>10</sub> life of 75,000 hours per ABMA 9, grease lubricated with cast iron bearing caps. Labyrinth sealed with removable grease relief plugs. Extended lubrication lines with Alemite fittings in both end shields. Provide for adding new and draining old grease without major motor disassembly.
  10. Hardware: Stainless steel.
  11. Shaft: High strength carbon steel, precision turned and ground. Non-metallic V-ring shaft slinger to prevent moisture seepage along shaft into motor.
  12. Power Factor Correction Capacitors (as required by applicable Specification Section and/or when shown on PLANS): Furnish capacitors of the greatest KVAR rating recommended by motor manufacturer for switching with motor. Capacitors to be provided with appropriate drain resistors per NEC and located inside motor terminal box. Furnish oversize terminal box when capacitors are required.

13. Provide internal temperature switch with contacts rated for 120 VAC, 5 amps, when shown on the PLANS. Switch settings to be at appropriate protection temperature.
14. Nameplate: Stainless steel securely attached to motor with stainless steel screws. All data to be permanently stamped into nameplate. Data to include:
  - a. Horsepower.
  - b. RPM.
  - c. NEMA design.
  - d. Phase.
  - e. Hertz.
  - f. Service factor.
  - g. NEMA nominal efficiency.
  - h. Power factor.
  - i. Frame size.
  - j. Duty.
  - k. Class of insulation.
  - l. Ambient temperature.
  - m. Locked rotor KVA code.
  - n. Full load amps.
  - o. Locked rotor amps.
  - p. Bearing identification by ABMA number.
  - q. Model and catalog number.
  - r. When power factor correction is provided in motor circuit, an auxiliary stainless steel nameplate to be securely attached to respective motor with stainless steel screws. Auxiliary nameplate to read “\_\_\_ FLA with \_\_\_ KVAR power factor correction capacitor installed”, with applicable values inserted as required. Sentence to be permanently stamped into auxiliary nameplate.
  - s. Each motor is to have a stainless steel nameplate indicating essential lubrication information such as the type of lubricant, viscosity, frequency of lubrication, etc.
15. Additional Features for Motors Sized 200HP and Larger:
  - a. Motor space heaters and temperature switch wired to a separate terminal box.
  - b. Provide internal temperature switch with contacts rated for 120 VAC, 5 amp. Switch settings to be at appropriate protection temperature.
16. Additional Features for Motors with Power Factor Correction:
  - a. High voltage terminal cabinet to be cast or fabricated steel of NEMA 4X construction, complete with hinged front doors with locking handle. Sized large enough to permit full stress cone terminations within the enclosure and to contain power correction capacitors, if required. Provide with ground lug and cable clamps for terminations. Motor leads into and out of cabinet to be sealed watertight.
  - b. Low voltage terminal cabinet, of like construction to the high voltage cabinet, complete with terminal blocks. Each terminal block is to contain ten (10) spare terminal points.
  - c. Capacitors to be provided when power factor correction is required. The capacitors to be installed in the high voltage terminal cabinet box. The terminal box to be sized large enough to house the capacitors.
17. Inverter Duty Motors:
  - a. Variable speed drive motors are to be designed for pulse-width modulated inverter duty. Motor nameplate to note inverter duty classification.
  - b. Motors to be used for inverter duty to meet requirements of NEMA MG 1, Section IV, Parts 30 and 31.
  - c. Bearings to be electrically isolated to prevent stray current damage.

- d. Provide internal temperature switch with contacts rated for 120 VAC, 5 amp. Switch settings to be at appropriate protection temperature.
- e. Any limitations or caveats such as circuit length, cable type, or variable frequency drive characteristics are to be clearly identified in the submittal and meet the requirements shown on the PLANS and specified elsewhere in other Specification Sections.

**2.03 (NOT USED)**

**2.04 SOURCE QUALITY CONTROL**

- A. Factory Tests:
  - 1. Perform routine (production) tests on all motors in accordance with NEMA MG 1 and IEEE 112.
  - 2. For motors 100 HP and smaller, testing can be conducted on an identical motor.
  - 3. Testing:
    - a. No load power at rated voltage.
    - b. Locked rotor current.
    - c. Efficiency at 50, 75 and 100 percent of rated horsepower in accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraphs 12.59 and 12.60.
    - d. Power factor.
    - e. Speed.
    - f. Current at rated horsepower.
    - g. kW input at rated horsepower.
  - 4. Motors larger than 100 HP are to be given a five point vibration test.
- B. Test Report Forms:
  - 1. Routine Tests: IEEE 112, Form A-1.
  - 2. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Table 12-11.

**PART 3 EXECUTION**

**3.01 - 3.02 (NOT USED)**

**3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION**

- A. Follow manufacturer's published instructions and alignment requirements for driven unit. Measure and record amperes at maximum load and verify proper overload heater selection.

**3.04 - 3.10 (NOT USED)**

**3.11 MEASUREMENT AND PAYMENT**

No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

**END OF SECTION**

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## **SECTION 16150**

### **RACEWAYS, FITTINGS AND SUPPORTS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. This section specifies raceways, fittings, and supports for all cables, conductors and electrical equipment. The Contractor shall furnish and install complete raceway systems in accordance with the following specifications and as also shown on the PLANS.
- B. Refer to the conduit/wire schedule shown on the PLANS for a listing of proposed raceways and other requirements. The conduit/wire schedule shown on the PLANS is not inclusive of all equipment required by this Contract. Refer to Part 2 of this section for additional requirements.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors. Suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

##### **1.03 REFERENCES**

- A. The publications listed below form a part of this specification to the extent referenced. The Publications are references in the text by designation only.
- B. This section contains references to codes and standards. They are a part of this section as specified. In case of conflict between the requirements of this section and the listed standards, the requirements of this section shall prevail. All raceways, fittings and supports are to be U.L. listed and certified and shall conform to ANSI and NEMA standards.

##### **1.04 SUBMITTALS**

- A. The Contractor shall submit manufacturer's catalog data for all material provided under this section and in accordance with the requirements of Section 01300 and 01730 of the Specifications. The Contractor shall submit certified notification from the Manufacturer that the rigid aluminum conduit system and all related materials, as described within this specification, is 99.0 percent copper-free.

1. Submit certifications of training associated with proper installation the PVC coated rigid galvanized conduit and Fiberglass conduit.
2. Submit Material Safety Data sheets for all sealants, solvents, etc.

## **PART 2 PRODUCT**

### **2.01 EXPOSED CONDUIT SYSTEM INDOOR, AND EXPOSED-OUTDOOR ABOVE GROUND LEVEL**

- A. General: All components shall be 99.0 percent copper free rigid aluminum.
- B. Rigid Metal Conduit System
  1. Conduit run above ground shall be rigid aluminum in all areas unless specifically specified otherwise hereinafter in subsection 3.02, this Section of the Specifications.
  2. Rigid Aluminum Conduit shall meet the following requirements
    - a. U.L. listed
    - b. Comply with ANSI C80.5 and U.L.6.
  3. Bending Requirements: Furnish factory bends. 90-degree bends of conduit sizes equal to or greater than 4-inches in diameter shall have a minimum bending radius of 48-inches unless otherwise noted on the PLANS. 90-degree factory bends of conduit sizes less than 4-inches in diameter, shall be per manufacturers standard unless otherwise noted on the PLANS.
  4. Minimum conduit size for all work shall be 3/4 inches.
  5. Manufacturer: VAW of America Inc., or approved equal.
- C. Conduit Hubs:
  1. Provide grounding type with integral threaded insulated throat, and with solderless grounding lugs, complete with rubber gasket.
  2. Manufacturer: by "Myers", or approved equal.
- D. Grounding Bushings:
  1. Provide with integral threaded insulated throat, and with solderless grounding lugs
  2. Manufacturer: "O.Z. Gedney" type ABLG with specified options, or approved equal.
- E. Conduit Bodies
  1. Conduit body covers shall be of the bolt-on type and shall have Type 316-Stainless Steel screws/hardware.
  2. Manufacturer: "Crouse-Hinds" Form-7, or approved equal..
- F. Conduit Unions: Threaded, as manufactured by "Crouse-Hinds" type UNF or UNY, or approved equal
- G. Conduit Reducers:
  1. Threaded.
  2. Shall be used for final conduit system connection to equipment where shown on the PLANS
  3. Manufacturer: "Crouse-Hinds" type RE and type REA, or approved equal.



- H. Cord and Cable Fittings:
  - 1. Provide threaded gland nut, straight threaded body, and also a neoprene sealing cable bushing.
  - 2. Furnished with a Type 316 Stainless Steel wire mesh grip
  - 3. Shall be used only where specifically shown on the PLANS.
  - 4. Manufacturer: "Crouse-Hinds" type CGB, complete with all specified accessories, or approved equal.
- I. Expansion Fittings:
  - 1. Furnished with oversized sleeve and insulated bushing
  - 2. Furnished with tinned copper braided bonding jumper
  - 3. Manufacturer: O.Z./Gedney Type EXPB-A, or approved equal
- J. Sealing Fittings:
  - 1. Furnish with drain
  - 2. Manufacturer: Crouse Hinds, Type EYD, or approved equal
  - 3. Sealing Compound:
    - a. Where conduit seals are installed in compliance with NEC Class-I and Class-II requirements, the sealing compound shall be as manufactured by "Crouse-Hinds" type Chico-AP, or approved equal.
    - b. Where conduit seals are not required for NEC Class-I and Class-II installations but are shown to be installed on the PLANS to block the migration of corrosive gases into the conduit system and conduit bodies, the conduit seals Sealing Compound shall be Scotchcast Reenterable Electrical Insulating Resin 2123 as manufactured by "3M", or approved equal.
    - c. Coordinate application with the Owner.
    - d. For vertical seals use mineral wool packing material to form a dam in the annular space around the conductors and hold the sealing compound in place while it cures. Packing material shall be as manufactured by "Crouse-Hinds" type Chico-X, or approved equal.
- K. Miscellaneous Requirements:
  - 1. Conduit nipples shall have two independent sets of threads.

## **2.02 UNDERGROUND CONDUIT IN DUCT BANK SYSTEM**

- A. General:
  - 1. Type: All components shall be non-metallic, except where noted herein and specifically shown otherwise on the PLANS. Refer to the PLANS.
  - 2. Bending Requirements: Furnish factory bends. 90-degree factory bends of conduit sizes equal to or greater than 4-inches in diameter shall have a minimum bending radius of 48-inches. Also, all 90-degree, 45-degree, and 30-degree conduit bends shall be factory made bends.
  - 3. Minimum conduit size for all work shall be 1 inch.
- B. Rigid Nonmetallic Conduit System
  - 1. All components shall be schedule 40 PVC, heavy wall, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 352 of the latest edition of the National Electrical Code (NEC).
  - 2. Solvent weld: Shall be a type approved by the conduit manufacturer.

3. Manufacturer: Conduit shall be as manufactured by "Prime Conduit", or approved equal.
- C. PVC Coated Rigid Galvanized Steel Conduit System
1. Material: Steel per UL 6 and ANSI C80.1, hot-dipped galvanized inside and out after the threads are cut.
  2. Exterior Coatings:
    - a. After galvanizing, the conduit/fittings shall be uniformly and consistently coated with a gray PVC coating of minimal 40 mil thickness. Exception: The threads shall be coated with urethane in lieu of PVC.
    - b. The PVC coating adhesion performance shall be ETL verified to the Intertek ETL SEMKO, High Temperature H<sub>2</sub>O PVC Coating Adhesion, Test Procedure for 200 hours.
  3. Interior Coating:
    - a. After galvanizing, the interior of conduit and fittings shall be uniformly and consistently coated with a urethane coating of nominal 2 mil thickness.
  4. Accessories: Threads shall be furnished with plastic thread protector caps.
  5. Manufacturer: Robroy Industries, Perma-Cote, or Plasti-Bond REDH<sub>2</sub>OT.
- D. Reinforced Thermosetting Resin Conduit (RTRC) Conduit System
1. General:
    - a. May be used only where specifically permitted by subsection 3.02.C.8, this Section of the Specifications.
    - b. Shall comply with NEC Article 355.
  2. Material:
    - a. Fiberglass, Reinforced Thermosetting Resin Conduit. Resin system shall be epoxy based, with no fillers, using an anhydride curing agent. The fiberglass shall consist of continuous E-glass Grade "A" roving. Conduit shall be low-halogen per UL 2515.
    - b. Manufactured using the single circuit filament winding process. Oven cured. Nominal winding angle of 54.75 degrees.
    - c. Carbon black shall be used as ultra violet inhibitor.
    - d. Internal walls shall be smooth with all fibers embedded in epoxy.
  3. Certifications: NEMA TC14, UL 2420 and 2515.
  4. Suitable for installation exposed outdoors and encased in concrete
  5. Fittings:
    - a. The following fittings shall be provided. Example part numbers shown hereinafter apply to the raceway system manufacturer specified hereinafter. All part numbers required for this project are not shown. Contractor to coordinate necessary part numbers with the manufacturer for a complete installation.
    - b. 90 degree bends with factory installed 2 deep socket PVC coupling and 1 fiberglass coupling bonded to elbow:
      - 1) For conduit sized 1" – 1 ½", provide type IPS. Example part number for 1": 10C-XW-90-2DF
      - 2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-90-2DF
    - c. Sleeve couplings:
      - 1) For conduit sized 1" – 1 ½", use type IPS. Example part number for 1": 10C-XW-42

- 2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-42
- d. Female Terminal Adapters:
  - 1) For conduit sized 1" – 1 ½", use type IPS. Example part number for 1": 10C-XW-32
  - 2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-32
- e. Straight Socket Conduit:
  - 1) For conduit sized 1" – 1 ½", use type IPS. Example part number for 1": 10C-XW-10S
  - 2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-20-S
6. Mix Epoxy Adhesive:
  - a. For ambient temperatures 40 - 70 degree F, provide type CM-2040-SFG
  - b. For ambient temperatures 70 degree F and above, provide type CM-2070-SFG.
7. Mix Epoxy Adhesive Mixing Tip and Gun:
  - a. Mixing Tip: CM-MT
  - b. Mixing Gun: CM-AG
8. Accessories: Provide with adhesive couplings, spigots, adapters, and other adhesive fittings as required to connect to the other specified raceways as shown on the PLANS.
9. Manufacturer: Champion Fiberglass "Haz Duct XW", no equal.

## 2.03 LIQUID TIGHT FLEXIBLE CONDUIT

- A. Sizes: - Greater than or equal to ¾ inch and smaller than or equal to 2 inch Flexible Conduit:
  1. Conduit Type: Non-metallic type liquid tight conduit, formed from PVC plastic
  2. Conduit Installation Temperature Range: –20 degrees Celsius to + 60 degrees Celsius (suitable for use outdoors and indoors)
  3. Conduit Manufacturer: ELECTRI-FLEX series NM type B-PVC, or approved equal.
  4. Fittings Type: Non-metallic PVC fittings
  5. Fittings Manufacturer: CARFLEX, or approved equal.
- B. Sizes:- Greater than 2 inch Flexible Conduit:
  1. Conduit Type: PVC-COATED metallic liquid tight conduit, formed from PVC plastic
  2. Conduit Temperature Range: –20 degrees Celsius to + 60 degrees Celsius (suitable for use outdoors and indoors)
  3. Conduit Manufacturer: SEALTITE, or approved equal.
  4. Fittings Type: 99.0 percent Copper-Free-Aluminum
  5. Fittings Manufacturer: Appleton, Crouse-Hinds, or approved equal.
- C. Minimum liquid-tight flexible conduit size for all work shall be ¾-inch unless specifically noted otherwise on the PLANS. Exception: ½" non-metallic conduit may be used for the final conduit connection to device with ½" threaded opening with prior Owner approval.

## **2.04 MISCELLANEOUS**

- A. Polyurethane foam duct sealant: FST-250 and FST-MINI Duct Sealant as manufactured by "Polywater", or approved equal
- B. Pipe Tape: 20 mil, 3M company No.51, or approved equal
- C. Conduit Sleeves
  - 1. Conduit sleeves shall be schedule 80 PVC, heavy wall, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 352 of the National Electrical Code (NEC).
- D. Conduit Hole Seals
  - 1. Hole seals shall be stainless steel, U.L. listed as NEMA 4X oil-tight, complete with oil-resistant gasketing, backplate, stud and wing nut. Hole seals shall be manufactured by Hoffman, Rittal, Cooper B-Line, or approved equal.
- E. Armored Cable Termination Fittings:
  - 1. Materials: 99.0 percent copper free aluminum body, gland nut, and armor stop bushing. Stainless Steel grounding/retaining spring. Neoprene bushing.
  - 2. Manufacturer: Crouse-Hinds "Terminator" TMC Cable Fittings, or approved equal.

## **2.05 ELECTRICAL EQUIPMENT AND RACEWAY SYSTEM SUPPORT CHANNELS**

- A. General requirements for all support channels:
  - 1. Channels located in all areas:
    - a. Type: Type 316-Stainless Steel
    - b. Manufacturer: "Unistrut Corporation" series P-1000ST and P-1001ST, or approved equal.
- B. All fastening hardware, fittings, supports, post bases, conduit clamps, beam clamps channel nuts, threaded rod, framing system, etc. shall be as follows:
  - 1. Items located in all areas:
    - a. Type 316 stainless steel
  - 2. Manufacturer: "Unistrut Corporation", or approved equal.
  - 3. Additionally, the following designations correspond to the following "Unistrut Corporation" series numbers as used in the details shown on the PLANS:
    - a. Items located in all areas:
      - 1) Beam clamps: "Unistrut Corporation" series P-2785ST and P-2786ST, or approved equal.
      - 2) Swivel fittings: "Unistrut Corporation" series M-2137ST, or approved equal.
      - 3) Post bases: "Unistrut Corporation" series P-2072AST and series P-2073AST, or approved equal.
      - 4) Hanger clevis fittings: "Unistrut Corporation" series P-2682ST, or approved equal.

- C. Expansion anchors shall be installed per the manufacturer's recommendations and shall be as follows:
  - 1. Anchors located in all areas:
    - a. Type 316-Stainless Steel. Anchors shall also be per Section 05051 "Anchorages".
  - 2. Also refer to the PLANS.

## **2.06 MANHOLES AND HANDHOLES**

- A. General requirements for Handholes:
  - 1. Vault shall consist of a 3" high base, 12' high body and 12" high extension, all constructed of precast reinforced concrete.
  - 2. Cover shall be a bolt-down, traffic rated type constructed of galvanized steel and marked with the word ELECTRIC.
  - 3. Handhole shall be a 17" x 30" Traffic Pull Box Model 6-T PB manufactured by Brooks, or approved equal.
- B. Refer to the PLANS and Specifications for manhole requirements.
- C. Provide all cable pulling eyes, cable support system components and accessories indicated on the PLANS and as otherwise required. Arrange support systems so that each cable can be securely anchored.
- D. The manhole structural wall opposite each duct bank penetration into the manhole shall be equipped with a cable pulling eye (one cable pulling eye per each duct bank penetration into the manhole). Position each pulling eye with coordinates (vertical elevation and horizontal alignment) to accommodate cable pulling and minimize cable pulling tension. Pulling eyes shall be bonded to the manhole wall structural reinforcement prior to pouring concrete. Pulling eyes may not be shown on the manhole vault structural PLANS, however, they are to be installed per the requirements of this specification.

## **2.07 CABLE SUPPORT SYSTEM IN UNDERGROUND ELECTRICAL MANHOLES AND HANDHOLES**

- A. General Requirements for support channels:
  - 1. Type: Type 316-Stainless Steel
  - 2. Manufacturer: "Unistrut Corporation" series P-1000ST and P-1001ST, or approved equal.
- B. All fastening hardware, fittings, supports, post bases, conduit clamps, beam clamps channel nuts, threaded rod, framing system, etc. shall be fabricated with Type 316 stainless steel, as manufactured by "Unistrut Corporation", or approved equal. Additionally, the following designations correspond to the following "Unistrut Corporation" series numbers as used in the details shown on the PLANS:
  - 1. Porcelain Clamps and Saddles-"Unistrut Corporation P1787A through P1795B Porcelain Cable Clamps", for both Electric and Communications and Instrumentation and Control.
  - 2. Surface Mounted Vertical Channels (Columns)-"Unistrut P-1000ST Type 316 stainless steel channels and accompanying Unistrut post bases".

3. Surface Mounted Horizontal Channels (side mounted channels)-“Unistrut P-1001ST Type 316 stainless steel channels and accompanying Unistrut post bases as well as wall mounted vertical channels”.
4. Brackets-“Unistrut” P-2515 ST of 15 inch length for Electric, and P-2542 ST of 15 inch length for Telephone and Communications. All parts given shall be Type 316 stainless steel.
5. Beam Clamps – “Unistrut” P-2785 ST”. All parts given shall be Type 316 stainless steel.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. Install electrical equipment and conduit raceway system in accordance with the recommendations of the manufacturer, the requirements of the latest edition of the National Electrical Code, and the PLANS. All cables/wiring shall be installed in a raceway system.
- B. Contractor shall be trained and certified by the PVC coated rigid galvanized steel conduit manufacturer in the proper installation of the PVC coated rigid galvanized conduit.
- C. Contractor shall be trained and certified by the Fiberglass conduit manufacturer in the proper installation of the Fiberglass conduit.

### **3.02 CONDUIT SYSTEM**

- A. General:
  1. Run conduits continuous from outlet to outlet, from outlets to cabinets, pull or junction boxes, etc.
  2. Install all conduits as a complete system before wiring is pulled in. Conduits shall be reamed, thoroughly cleaned of debris, and swabbed immediately before wire is pulled.
  3. Furnish and install expansion fitting for each conduit across structural expansion joints. Coordinate locations of expansion joints with the PLANS. Additionally, furnish and install additional appropriate fittings such as conduit unions, adapters, etc. as required for a complete installation.
  4. Conduit shall contain no more than the equivalent of three (3) 90-degree bends between outlets or pull points.
  5. Maintain a minimum 6-inch clearance between conduit and piping and a minimum 12-inch clearance between conduit and heat sources.
  6. Protect all coated conduit from accidental coating damage during storage and installation. Repair all damaged conduits in accordance with manufacturer's recommendations at no additional cost to the OWNER.
  7. Furnish and install temporary conduit closures during construction activities to prevent foreign matter from entering raceways.
  8. Furnish and install conduit measuring tape in each empty spare conduit as manufactured by Ideal Industries Incorporated or approved equal.

- B. Exposed Conduit System Indoor, and Exposed-Outdoor Above Ground Level:
1. Rigid conduit joints shall be cut square, threaded, reamed smooth and drawn up tight. Make field bends or offsets with an approved bender or hickey or hub type conduit fittings.
  2. Run conduit parallel or at right angles to building lines and such to avoid moisture traps.
  3. Arrange conduits to maintain headroom and present a neat appearance.
  4. Support conduit using support channels as shown on the PLANS and as specified herein.
  5. Coat all conduit threads with Penetrox or Noalox prior to assembly.
  6. Secure conduit runs firmly to specified support channels by conduit straps or by hangers, as required, and as shown on the PLANS.
- C. Underground Conduit in Duct Bank System
1. Install all underground conduit in concrete encased and steel reinforced duct banks.
  2. Concrete shall be Class 'A' per Section 403S "Concrete for Structures". A red admixture shall be added to the concrete at a rate of 12 pounds per cubic yard of concrete and per the requirements of Section 403S. Red admixture shall meet the requirements of ASTM C-979-82. Red admixture shall be as manufactured by ChemSystems, Inc. series HBS #120 Conduit Red, or approved equal. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS.
  3. Reinforcing Steel shall be per Section 406S "Reinforcing Steel" unless noted otherwise on the PLANS. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS.
  4. Install detectable underground warning tapes at 12-inches below finished grade along the entire length of each duct bank. Each tape shall be a minimum of 6-inches wide, 4 mil thick, laminated, and contain an aluminum foil core backing. The tape shall be detectable using a non-ferrous locator. The tape color shall be red and shall be labeled with the words "CAUTION BURIED ELECTRIC LINE BELOW" in black lettering. For duct banks less than 24-inches wide, install one length of tape aligned along the centerline of the duct bank. For duct banks 24-inches wide and larger, install two lengths of tape, with each length aligned with each edge of the duct bank along the width of the duct bank. Warning tape is not required along the length of the specific portion of a duct bank that is installed underneath a building concrete floor slab.
  5. Provide a minimum of 3-inches separation between conduits installed in concrete construction except at panelboards, pull or junction boxes and/or other locations where the conduits are grouped. Furnish and install plastic spacers as shown on the PLANS.
  6. Underground system conduits shall be installed with a minimum depth below finished grade of 24" to top of concrete envelope of duct bank and shall slope 3-inches per 100 feet from high points toward pull boxes and handholes/manholes, at minimum. Increase the minimum duct bank depths below finished grade as shown on the PLANS. Additionally, underground duct bank system shall be routed per the PLANS and coordinated with the depths of Civil/Structural foundations, beams, etc. No conduit shall be routed through grade beam slab of a building floor slab.

7. All underground conduit joints shall be watertight in accordance with the manufacturer's recommendations.
8. Transition from underground (underground work in duct bank) to above ground conduit as shown on the PLANS.
9. Where a duct bank penetrates a concrete structure, dowel between the duct bank and the structure at the point of penetration and tie the steel reinforcing rebar system of the underground duct bank system to the concrete structure and steel reinforcing rebar system of the concrete structure. Refer to the Civil/Structural Specifications and PLANS for additional requirements.
10. Where PVC coated rigid galvanized steel conduit is shown on the PLANS, Contractor may employ RTRC conduit in lieu of the PVC coated rigid galvanized steel conduit.
11. Where factory bends/elbows (11-1/4°, 22-1/2°, 30°, 45°, and 90°), as specified in Part 2.02 A 2 of this Specification, are not manufactured and field bends become necessary, field bends may be performed using a heat box type electric PVC conduit heater. The use of open flame to heat the PVC conduit is NOT permitted. Utilize a PVC conduit plug set to plug the ends of the conduit throughout the heating process and trap the air inside the conduit to help keep the PVC conduit from collapsing while forming the bend.

D. Conduit Penetrations:

1. Install sleeves for conduit penetrations of walls and floors unless shown otherwise on the PLANS. Install sleeves during erection of concrete and masonry walls. Exception: Sleeves are not required for conduits stub-ups through floor slab from underground duct bank.
2. Where aluminum conduit penetrates a wall/floor-slab and/or walls/floors of dissimilar material (other than Stainless Steel) or is in contact with dissimilar material, wrap the aluminum conduit with Pipe Tape using a 50 percent overlap throughout the entire distance/length of the penetration and an additional 6-inches of distance beyond either side of the penetration/contacted region.
3. Install pitch pans on conduits which penetrate through roofs.
4. Also refer to the conduit penetration details shown on the PLANS.

E. Miscellaneous:

1. Seal empty spare conduits (at above ground stub-ups) with an aluminum screw in plug sized to the trade size of the conduits.
  - a. Threaded insert plug shall have a square head and shall be constructed from copper-free Aluminum material.
  - b. Threaded insert plug shall be Type CUPX by Hubbell-Killark, Type PLG by Crouse-Hinds, or approved equal.
2. Seal and pack/fill ends of each conduit with polyurethane foam duct sealant.
3. In all sealing fittings, utilize sealing compound to seal around and between each conductor and associated sealing fitting body.

F. Requirements for cables inside of Manholes, Handholes, etc.:

1. Arrange cables so that there is a minimum of crossing. Provide slack in each cable.
2. Secure cables in handholes/manholes on support channel system as specified herein and as shown on the PLANS.



- G. Connections to Equipment:
  - 1. Liquid tight flexible conduit shall be used for connections to motors, field instruments, etc., and any equipment subject to vibration, and where shown on the PLANS. Length of conduit shall not exceed 36-inches, unless specifically noted otherwise on the PLANS or approved by the Owner.

### **3.03 INSTALLATION OF SUPPORT CHANNELS**

- A. Utilize support channels and mounting hardware as previously specified to install raceways, and any other surface mounted electrical, instrumentation and control equipment. Refer to details shown on the PLANS. Use 316 stainless steel split ring lock washers with mounting hardware when installing support channels.
- B. Whenever support channels are cut in the field, the cut ends shall be filed smooth and shall be cleaned using liberal amounts of a contact cleaner to remove all residual elements from the cutting and filing process. Coat all field cut ends with cold galvanizing paint.

### **3.04 INSTALLATION OF HANDHOLES**

- A. Handhole shall be installed where shown on the PLANS.
- B. Handhole shall be set so that the top of the handhole and its associated cover are flush with the finished concrete surface in which the handhole is placed.
- C. Coordinate handhole installation with Civil/Structural. At minimum, install the handhole in accordance with the handhole manufacturer's recommended installation procedure.

### **3.05 HOUSEKEEPING CONCRETE PAD FOR EQUIPMENT**

- A. Provide housekeeping concrete pad for all outdoor equipment whether it is free-standing or surface mounted. All housekeeping pad edges shall be chamfered. Outdoor electrical equipment pads shall be as detailed on the PLANS.
- B. Provide housekeeping concrete pad for indoor all free-standing equipment. Indoor electrical equipment pads shall be as detailed on the PLANS.

### **3.06 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this section. Include cost of same in Contract price bid for work of which this is a component part.

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## **SECTION 16200**

### **WIRING (600 VOLTS AND BELOW)**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Furnish and install the field wiring as specified herein and as shown on the PLANS.
- B. Furnish and install all wiring required to make the electrical system completely and satisfactorily operable. Comply with the National Electrical Code and all applicable federal, state, and local codes, regulations and ordinances.
- C. The requirements of this section also apply in whole to the installation of the fiber-optic cables and Ethernet copper cables. Fiber optic cables are specified in Section 17600 "Distributed Control System" of the Specifications.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. The PLANS designate the type, number, and size of field wiring.
- D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

##### **1.03 SUBMITTALS**

- A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

#### **PART 2 PRODUCTS**

##### **2.01 GENERAL REQUIREMENTS**

- A. All wire and cable on this project shall be new, unused, in good condition and shall be delivered in standard coils, packages or reels. Submit wire samples when requested by the OWNER. Final acceptance of wire shall be made by the OWNER or its representative.

## 2.02 SINGLE CONDUCTOR - GENERAL ELECTRICAL POWER SYSTEM AND AUXILIARY ELECTRICAL SYSTEM WIRING

- A. All wire shall be 98% conductivity copper, stranded, single conductor Type XHHW-2. This wire shall have moisture resistant insulation and clean stripping characteristics. Wire shall be marked at minimum distance of every ten feet (10') with the size, type and voltage of the wires as well as the manufacturer's name and measurement markers. All neutral and ground wires shall be insulated and identified and marked.

- B. The pigmentation of the wire insulation shall conform to the color table listed below:

Phase	277/480 Volts	120/208 Volts AC	24 Volts DC
ΦA	Brown	Red	-----
ΦB	Yellow	Black	-----
ΦC	Purple	Blue	-----
Neutral	Gray	White	-----
Ground	Green	Green	Green
Motor Space Heater (H)	-----	Black	-----
DC (+)	-----	-----	Blue
DC (-)	-----	-----	Brown

- C. Any interlock wiring installed in one device with power from another device shall be properly marked.
- D. The minimum wire size shall be No.10 for all wiring unless shown otherwise on the PLANS.
- E. Departures from the sizes shown shall be made only in those cases in which the National Electric Code requires the use of larger conductors.
- F. General Electrical Power System and Auxiliary Electrical System Wiring shall be as manufactured by General Cable Company, The Okonite Company, or approved equal.

## 2.03 SIGNAL AND COMMUNICATION WIRING

- A. 4-20 Milliamp Signal wiring:
1. Number of Pairs: One
  2. Wire Size: #16 AWG
  3. Type of Conductors: Stranded copper conductors, twisted
  4. Individual Conductor Insulation: PVC
  5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White.
  6. Drain Wire: Tinned copper
  7. Overall Shield: Aluminum-mylar shield.
  8. Overall Jacket: PVC
  9. Overall Jacket Color: Black.

10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1852 or approved equal.

## **2.04 SINGLE CONDUCTOR CONTROL WIRING**

- A. Single conductor control wiring shall be 98% conductivity copper, stranded, single conductor Type XHHW-2. This wire shall have moisture resistant insulation and clean stripping characteristics. Wire shall be marked at minimum distance of every ten feet (10') with the size, type and voltage of the wires as well as the manufacturer's name and measurement markers.
- B. Conductors shall have a minimum size of #14 AWG, unless shown otherwise on the PLANS. The color of the wire shall be RED.
- C. Single Conductor Control Wiring shall be as manufactured by General Cable Company, The Okonite Company, or approved equal.

## **2.05 GENERAL ELECTRICAL POWER SYSTEM AND AUXILIARY ELECTRICAL SYSTEM ARMORED CABLE**

- A. General: Multi-Conductor power system and auxiliary electrical system armored cables shall be rated 600 volts. Cables shall be suitable and rated for installation in wet or dry locations, for AC or DC service at conductor temperatures of 90 degrees C. Cable shall be suitable and rated for open runs of cable, installation in conduit system, cable trough system, cable tray system, and directly buried in the ground/earth.
- B. Features: As minimum, the Multi-Conductor armored power cables shall have the following features:
  - 1. UL Listed as type MC-HL cable as well as Marine Shipboard Cable
  - 2. Passes the IEEE 383 and IEEE 1202 vertical tray flame tests.
- C. Conductors: Each individual conductor in each multi-conductor cable (inclusive of grounding conductor) shall be copper per ASTM B-3. Each conductor shall have the following additional features:
  - 1. Stranding:
    - a. Conductor Sizes Smaller than No. 8 AWG: Stranded per ASTM B-8
    - b. Conductor Sizes Equal To and Larger than No. 8 AWG: Stranded per ASTM B-496.
  - 2. Insulation: Cross linked polyethylene insulation listed to UL Type XHHW-2
  - 3. Conductor Identification: Each conductor shall be uniquely identified per the manufacturer's standard method. Color coded insulation per 2.02.B, this Section of the Specifications, is preferred.
  - 4. Size of each conductor shall be as shown on the Conduit/Wire Schedule shown in the PLANS.
- D. Overall Armor Sheath: Close fitting, impervious, welded, corrugated aluminum C-L-X per UL 1569.
- E. Overall Outer Jacket: Each multi-conductor cable shall be covered with overall black PVC jacket. Minimum jacket thickness is 50 mils.

- F. Number of conductors in a cable: Number of conductors shall be as shown on the Conduit/Wire Schedule shown in the PLANS. Note: The cable armor shall not be considered as the equipment grounding conductor.
- G. Manufacturer: Okonite-C-L-X Type MC-HL (XHHW-2), or approved equal.

## 2.06 MULTI-CONDUCTOR CONTROL SHIELDED CABLE

- A. General: Multi-Conductor control system shielded cables shall be rated 600 volts. Cables shall be suitable and rated for installation for AC or DC service in wet or dry locations at conductor temperatures of 90 degrees C. Cable shall be suitable and rated for open runs of cable, installation in conduit system, cable trough system, cable tray system, and directly buried in the ground/earth.
- B. Features: As minimum, the Multi-Conductor shielded control cables shall have the following features:
1. Passes the IEEE 383 and IEEE 1202 vertical tray flame tests.
- C. Conductors: Each individual conductor in each multi-conductor cable shall be copper per ASTM B-3. Each conductor shall have the following additional features:
1. Stranding: Class B stranding per ASTM B-8
  2. Insulation: Heat moisture, flame and chemically resistant ethylene-propylene compound. Minimum insulation thickness is 30 mils.
  3. Conductor Identification: Color coded using base colors and tracers according to the following:

Conductor Size	Number of Conductors in a cable	Conductor Insulation Thickness	Cond. No.	Color Code	
				Base Color	Tracer(s)
#12 AWG	Nineteen (19)	30 mils	1	Black	----
			2	White	----
			3	Red	----
			4	Green	----
			5	Orange	----
			6	Blue	----
			7	White	Black
			8	Red	Black
			9	Green	Black
			10	Orange	Black
			11	Blue	Black
			12	Black	White
			13	Red	White
			14	Green	White
			15	Blue	White
			16	Black	Red
			17	White	Red
			18	Orange	Red
			19	Blue	Red
			1	Black	----
			2	White	----
			3	Red	----
			4	Green	----

Conductor Size	Number of Conductors in a cable	Conductor Insulation Thickness	Cond. No.	Color Code	
				Base Color	Tracer(s)
#12 AWG	Thirty Seven (37)	30 mils	5	Orange	----
			6	Blue	----
			7	White	Black
			8	Red	Black
			9	Green	Black
			10	Orange	Black
			11	Blue	Black
			12	Black	White
			13	Red	White
			14	Green	White
			15	Blue	White
			16	Black	Red
			17	White	Red
			18	Orange	Red
			19	Blue	Red
			20	Red	Green
			21	Orange	Green
			22	Black	White & Red
			23	White	Black & Red
			24	Red	Black & White
			25	Green	Black & White
			26	Orange	Black & White
			27	Blue	Black & White
			28	Black	Red & Green
			29	White	Red & Green
			30	Red	Black & Green
			31	Green	Black & Orange
			32	Orange	Black & Green
			33	Blue	White & Orange
			34	Black	White & Orange
			35	White	Red & Orange
			36	Orange	White & Blue
			37	White	Red & Blue

- D. Size of each conductor and quantity of conductors: There shall be two kinds of multi-conductor control cables: Nineteen (19) conductor (#12 AWG) cables, and Thirty Seven (37) conductor (#12 AWG) cables. Sizes and quantities shall be as shown on the Conduit/Wire Schedule shown in the PLANS.
- E. Shield: 5 mil longitudinal corrugated copper tape.
- F. Overall outer jacket: Each multi-conductor cable shall be covered with overall thermoset chlorinated polyethylene compound outer jacket resistant to moisture, ozone, oil and most chemicals. Minimum jacket thickness is 80 mils.
- G. Number of conductors in a cable: Number of conductors shall be as shown on the Conduit/Wire Schedule shown in the PLANS. Note: The cable shield shall not be considered as the equipment grounding conductor.

H. Manufacturer: Okonite FMR-LCS Okolon TS-CPE, or approved equal.

## **2.07 WIRE TAGGING**

- A. Wire Tags:
1. Rating: Flame-Retardant,
  2. Style: Heavy-Duty Industrial Grade
  3. Type: Heat Shrinkable type.
  4. Character Height: 1/8 inch.
  5. Maximum Length: 2 inches.
  6. Text Type: Typed with indelible marking process. Handwritten shall not be accepted.
  7. Color: White.
    - a. Exception: Use Yellow for instrumentation/control circuits as described in Section 17200.
  8. Manufacturer: "Raychem type Heavy-Duty Industrial Grade ShrinkMark Heat-Shrinkable Marking Sleeves", or approved equal. Utilize "Raychem" Portable-Marking-System" complete with wire tag cartridges, or approved equal.

## **2.08 MISCELLANEOUS**

- A. Wire Pulling Lubricant: Ideal ClearGlide, or approved equal
- B. Multi-Cable Connector Blocks:
1. Use only for power wiring termination for motors rated 600V and below
  2. 600V rated
  3. Insulated with UV rated chemical resistant plastisol compound that will not support combustion
  4. Suitable for use with fine stranded extra-flexible wiring
  5. Suitable for use with aluminum and copper conductors
  6. U. L. 486A Listed
  7. Pre-filled with an oxide inhibitor.
  8. Manufacturer: "Polaris Connectors" Series Polaris Grey, or approved equal.
- C. Submersible Splice Connectors
1. Use only where indicated on the PLANS for submersible applications of 600V and below power and control wiring terminations.
  2. 600V rated
  3. Manufactured from high strength 6061-T6 aluminum alloy
  4. Encapsulated in rubber with a nominal thickness of 125 mils. And high dielectric strength.
  5. Suitable for use with aluminum and copper conductors
  6. U.L. 486D Listed
  7. Manufacturer: "Polaris Connectors" Series ISPBS Submersible Splice Connectors and Series ISPB2/0 and ISPB02/0 Submersible Streetlight Connectors, or approved equal.
- D. Corrosion Resistant and Moisture Repelling Electrical Coating/Spray:
1. Color: Clear. Coordinate spray color with the Owner. Furnish and install the color requested by the Owner at No Additional Cost to the Owner.
  2. Type: Corrosion resistant and moisture repellant fast drying spray coating sealant



3. Manufacturer: "3M" 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Before wire is pulled into any conduit, thoroughly swab the conduit to remove all foreign material and to permit the wire to be pulled into a clean, dry conduit. Use wire pulling lubricant in pulling any wire. Pull all conductors into their respective conduits by hand except where written permission of the OWNER is secured to the contrary.
- B. No wire splices shall be accepted except as permitted below:
  1. **SPLICING OF 208/120 VOLT LIGHTING AND RECEPTACLE CIRCUITING:**
    - a. General: Perform all splicing in splice/junction boxes dedicated for this purpose.
    - b. For splices where wiring is:
      - 1) #10 AWG and smaller: Utilize 600 volts WeatherProof Wire-Nut Wire Connectors. The WeatherProof Wire-Nut Wire Connectors shall be twist-on type and shall be pre-filled (factory- filled) with Silicone-Based Sealant for maximum protection against Moisture and Corrosion. The WeatherProof Wire-Nut Wire Connectors shall be as manufactured by IDEAL Model 61, 62, or 63 WeatherProof Wire-Nut Wire Connectors, or approved equal.
      - 2) All other sizes: Use the Multi-Cable Connector Blocks as Specified in 2.08.C, this Section of the Specifications.
- C. For wiring termination to motors rated 600 volt and below, use the Multi-Cable Connector Blocks as Specified in 2.08.C, this Section of the Specifications.
- D. All wiring connections must be insulated with 600 volt insulation system
- E. Tagging:
  1. Tag all power, Instrumentation and Controls and all other types of auxiliary electrical wiring and cables at both ends with the specified heat shrinkable tags and heat shrink tags.
  2. Tag per Subsection 3.03 of this Section of the Specifications and per the OWNER's cable and wire tagging standards.
  3. Tag each wire in a Multi-Conductor cable in addition to the overall cable itself.
  4. Group wiring routed in pullboxes that are routed in common conduits and tag each wiring group inside each pullbox with nameplates as follows:
    - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
    - b. Color: White-Black-White.
    - c. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer.
    - d. Accessories: Provide holes for mechanical fastening.

5. Secure each phenolic tag (where required) with a minimum of two nylon cable ties, one at each end of the tag.
- F. Ground shielded instrument cables at one point only, i.e.; at the final destination in the associated instrument and control cabinets.
- G. Terminate stranded wiring by use of lugs, clamps or pressure type terminals.
- H. After all wiring connections have been made, the Contractor shall apply the Corrosion Resistant and Moisture Repelling Electrical Coating/Spray to all wiring connections. Coordinate application with the Owner prior to application, the Owner has the discretion to limit application. For bidding purposes, the minimum extent of spray application is further clarified as follows:
  1. Spray shall be applied for all terminations of the following types of connections at a minimum:
    - a. termination points, terminals, terminal blocks, ground bar, neutral bar/bus,
    - b. lugs of circuit breakers, buses, doors, etc.
    - c. exposed/stripped ends of each conductor, etc.
    - d. bolt-on connections, split-bolt connections, ring lugs, etc.
    - e. submersible splice connectors, compression connectors, multi-cable connector blocks, etc.
    - f. all other connection types not listed above
  2. Spray shall be applied for all terminations at the following types of equipment at a minimum:
    - a. Local and main control panels, field instruments, junction boxes, field control stations, control relays, signal isolators, selector switches, pushbuttons, etc.,
    - b. Panelboards, transformers, motor control centers, manual motor starters, contactors, light switches, light fixtures, etc.
    - c. Motor termination enclosures, valve actuators, cathodic protection system, package control panels of process equipment, etc.
    - d. Security system devices, cameras, roadway gate operators, etc.
    - e. Convenience receptacles, scada receptacles, etc.
    - f. All other types of equipment not listed above.
- I. Additional requirements for armored cable installation:
  1. Furnish and install an armored cable termination fitting per Section 16150 for each armored cable termination point.
  2. Furnish and install supports for armored cable that are spaced in the appropriate intervals per the recommendations of the armored cable manufacturer and the NEC. Support channel and framing support system shall be per the conduit support requirements shown on the PLANS.
  3. Secure armored cable to support channel using UNISTRUT Cush-A-Clamp Assembly Pipe/Tube Clamp (1-5/8" Series), or approved equal, with controlled squeeze shoulder bolt for all clamping of armored cable.

### **3.02 TESTS**

- A. Perform all tests as outlined in Section 16800 and all other tests which are necessary to determine that the electrical wiring system is in satisfactory operating condition. Wiring shall be tested end-to-end after it is pulled in the conduit system.

### 3.03 WIRE TAGGING METHODOLOGY

#### A. Single Conductor Wire Tagging Scheme:

1. All single conductor control and power wiring shall be tagged utilizing the source and destination method. In general, as minimum each tag shall be comprised of various fields which are:
  - a. Device Identifiers,
  - b. Terminal Numbers and,
  - c. Equipment Identification name
2. The following is the format that shall be used for each control power single conductor wire tag:

XXXX	-	XX	(XXXX-XXXX-XXXX)	/	XXXX	-	XX)
Device Identifier		Terminal Number	Equipment Identification Name		Device Identifier		Terminal Number

- a. The tag information to the left refers to the point of termination. Tag information in parenthesis refers to the point of origination. Note: For wiring within the boundaries of a piece of equipment, The Equipment identification name shall not be required, only the Device Identifier and the Terminal Number from the point of origination. Examples to this exception would be, wiring from one terminal strip to another within the same control panel, etc.
3. The following provides a brief description to each of the fields required within a single wire tag:

FIELD	DESCRIPTION
Device Identifier:	A four (4) alphanumeric character field that shall uniquely identify a device within a piece of equipment. Examples are: TB1, for Terminal Block Number 1, and CR02 for Control Relay #02, etc.
Terminal Number:	A two (2) alphanumeric character field that shall identify which specific point on the Device the wire must be terminated to. Refer to manufacturer's labeling or record drawings for Device Terminal Numbers.
Equipment Identification Name:	A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the equipment.

#### B. Single Conductor Wire Tagging Scheme in a Multi-conductor Cable:

1. All single conductor control and instrument wiring (in Multi-conductor Instrument or Control Cables) shall be tagged utilizing the source and destination method. In general, each tag shall be comprised of various fields which are 1) Device Identifiers, 2) Terminal Numbers, and 3) Equipment Identification Name, as minimum.
2. The following is the format that shall be used for each single conductor wire tag in a multi-conductor cable (Instrumentation or Control wiring Cables):

XXXX	-	XX	(XXXX	/	XX)
Device Identifier		Terminal Number	Cable ID		Conductor Number

- a. The tag information to the left refers to the point of termination. Tag information in parenthesis refers to the point of origination.
3. The following provides a brief description to each of the fields required within a single tag (in a Multi-conductor Cable):

FIELD	DESCRIPTION
Device Identifier:	A four (4) alphanumeric character field that shall uniquely identify a device within a piece of equipment. Examples are: TB1, for Terminal Block Number 1, and CR02 for Control Relay #02, etc.
Terminal Number:	A two (2) alphanumeric character field that shall identify which specific point on the Device the wire must be terminated to. Refer to manufacturer's labeling or record drawings for Device Terminal Numbers.
Cable Identification (Cable ID):	<p>A five (5) alphanumeric character field that shall uniquely identify a cable within the facility. The first character shall identify the cable type as follows:</p> <p>C - for Control Cables  I - for Instrumentation Cables  P - for Power Cables</p> <p>The remaining four (4) alphanumeric characters shall make-up a unique number for a given cable type within the facility.</p>

- C. Overall Cable Tag of a Multi-conductor Cable:
- In addition to tagging each single conductor in a multi-conductor cable (as described in 3.03 B, above), the overall jacket of each multi-conductor cable shall also be tagged to uniquely identify each cable within the facility. In general, each cable tag shall be comprised of various fields which are 1) Cable Identification (Cable ID), and 2) Equipment Identification Name, as minimum.
  - The following is the format that shall be used for overall cable tag of each multi-conductor cable:

XXXX	(XXXX-XXXX-XXXX	/	XXXX-XXXX-XXXX)
Cable ID	Source Equipment Identification Name.		Destination Equipment Identification Name

- a. The tag information to the left refers to the actual cable Identification (name). Tag information in parenthesis refers to the Identification Name of the Equipment at point of origination (source), followed by the Identification Name of the Equipment at the point of termination (Destination Point).
3. The following provides a brief description to each of the fields required within a cable tag:

FIELD	DESCRIPTION
- Cable Identification (Cable ID):	A five (5) alphanumeric character field that shall uniquely identify a cable within the facility. The first character shall identify the cable type as follows:  C - for Control Cables I - for Instrumentation Cables P - for Power Cables  The remaining four (4) alphanumeric characters shall make-up a unique number for a given cable type within the facility.
- Source Equipment Identification Name:	A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the source (origination) equipment.
- Destination Equipment Identification Name:	A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the destination equipment (equipment at point of termination).

4. All cable tags (except in Manholes, handholes, above ground cable closets, and in cable tray system), shall be of 3-ply engraved plastic (phenolic) with background color, letter sizes, etc. as follows:

Cable Type	Tag Color	Color of Lettering	Letter Height
600 volt Power Cable	Orange	White	3/16" (min.)
600 volt Control Cable	Orange	White	3/16" (min.)
Instrumentation Cable	Black	White	3/16" (min.)

### 3.04 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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## **SECTION 16250**

### **BOXES AND CABINETS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Furnish and install all cabinets, junction boxes, pull boxes and outlet boxes as shown on the PLANS, required by the Specifications or National Electrical Code (NEC), or as otherwise necessary for a satisfactory operating system.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

##### **1.03 SUBMITTALS**

- A. Submit shop drawings in accordance with the Section 01300 of the Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

#### **PART 2 PRODUCTS**

##### **2.01 JUNCTION AND PULL BOXES**

- A. Lighting and power, signal, telephone, voice communication, instrumentation and controls, and any other junction and pull boxes hereinafter specified or shown on the PLANS shall be as provided as follows:
  - 1. Outdoor boxes shall be NEMA-4X Type 316-Stainless Steel Boxes. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.
  - 2. Indoor boxes in non-environmentally controlled rooms shall be as follows:
    - a. All areas:
      - 1) Smaller than or equal to 12" wide x 12" high: 99.0% copper-free rigid Aluminum NEMA-4X corrosion resistant and water tight boxes.
      - 2) Larger than 12" side x 12" high: NEMA-4X Type 316-stainless steel Boxes.
    - b. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.

3. Indoor boxes in environmentally controlled rooms shall be as follows:
  - a. NEMA 12 with ANSI No. 61 Gray finish
  - b. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.
- B. Boxes or cabinets shall be not less than 6-inches deep and their minimum height and width dimensions shall be determined by the requirements of, and in compliance with the NEC.
- C. Each type of box and cabinet on the project shall be manufactured by a single manufacturer.
- D. Manufacturer:
  1. Hoffman Concept Series, Rittal, Millbank, or approved equal.

## **2.02 NAMEPLATES**

- A. General:
  1. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted
  2. Color: White-Black-White
  3. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer
  4. Accessories: Provide holes for mechanical fastening. Provide adhesive backplane where required in Part 3, Execution.

## **PART 3 EXECUTION**

### **3.01 APPLICATION**

- A. General:
  1. Pullboxes shall be used only to reduce the number of bends for conduit, supports, taps, troughs and similar applications. No splicing shall be performed in pullboxes.
  2. Junction boxes shall only be used where shown on the PLANS. Any other use of junction boxes other than for receptacle and lighting circuit wiring, is not permitted.
  3. Outlet boxes shall be used for ceiling or wall mounting of light fixtures, receptacles, open type manual motor starters, and where required by the PLANS and Specifications to facilitate proper connection to equipment.

### **3.02 INSTALLATION**

- A. Set box square and true with building surfaces. Secure boxes firmly to support channels. Coordinate final location of boxes with other trades to avoid any conflicts.
- B. Utilize specified support channels, then secure/mount boxes and cabinets to the support channels. All mounting hardware shall be Type 316-stainless steel. Equipment support channels shall be per the requirements of Section 16150



“Raceways, Fittings, and Supports”. Additionally, refer to details shown on the PLANS.

- C. Tagging:
  - 1. Tag each box with the name as it appears on the PLANS using the specified namplates.
  - 2. Attach identification nameplates with two stainless steel screws.
- D. Cap all outlets not used under this Contract with blank outlet covers.
- E. Furnish and install labels as required by the NEC.

### **3.03 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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## **SECTION 16540**

### **FIELD CONTROL STATIONS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Furnish and install field control stations as specified herein and as shown on the PLANS.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

##### **1.03 SUBMITTALS**

- A. Submit shop drawings in accordance with the Section 01300 of the Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

##### **1.04 SPARE PARTS**

- A. Furnish 25% spare indicating pilot light assemblies for each type used (minimum of 1 per type).
- B. Furnish 50% of spare indicating pilot light lenses and lamps for each type and color size and type used (minimum of 2 per type).

#### **PART 2 PRODUCTS**

##### **2.01 PUSHBUTTONS, SELECTOR SWITCHES, PILOT LIGHTS**

- A. General:
  - 1. Rating: NEMA 4X/13, heavy duty, oil tight/corrosion resistant and rated for use in wet locations.
  - 2. Size: NEMA Style full size 30-millimeter (30mm)
  - 3. Contacts: 10 ampere minimum at 120 volts A.C. Stackable contact blocks. Provide number of contacts to satisfy the requirements of the PLANS.

4. Legend Plate: Provide per manufacturer's standard with inscription as shown on the PLANS.
  5. Manufacturer: Allen Bradley Bulletin 800H, or approved equal.
- B. Additional Requirements for Selector Switch/ Pushbuttons:
1. Operator Color: Black, unless shown otherwise on the PLANS.
  2. Selector Switch Action Type: Maintained action, unless shown otherwise on the PLANS.
  3. Pushbutton Action Type: Momentary action, unless shown otherwise on the PLANS.
- C. Additional Requirements for Pilot Lights:
1. Type: Transformer Type Light Emitting Diode (LED)
  2. Voltage: 120 volts A.C.
  3. Style: Push-to-test
  4. Lens Color: Provide the colors as shown on the PLANS:
- D. Additional requirements for Emergency Stop/Trip Push-Button Stations:
1. Action Type: Push-Pull maintained
  2. Operator Type: Mushroom head
  3. Operator Color: Red, unless shown otherwise on the PLANS
  4. Each button shall be provided with a hinged polycarbonate corrosion resistant locking cover. Cover shall be capable of closing without actuating the push button. Cover shall be C3 Controls Model LOAFC, or approved equal.
  5. Padlock: Furnish and install padlock with 0.25 inch diameter padlock shackle. Coordinate the shackle diameter with the padlock attachment. Furnish and install padlock as manufactured by Master Lock, or approved equal.

## **2.02 FIELD CONTROL STATION ENCLOSURE**

- A. Size: As required
- B. Rating: NEMA-4X
- C. Material: Type 316 Stainless Steel.
- D. Doors and door latches: Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.
- E. Manufacturer: Allen-Bradley, Hoffman, Rittal, Millbank, or approved equal.

## **2.03 LEGEND PLATES/NAMEPLATES FOR CONTROL STATIONS**

- A. General:
1. Provide nameplates/legend plates for each control station, and each pilot device installed in a control station as shown on the PLANS and as previously specified.
- B. Identification Nameplates:
1. General: Furnish and install identification nameplates for each field control station as follows unless shown otherwise on the PLANS
    - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall

be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.

- b. Color: White-Black-White
- c. Lettering: 1/4-inch height minimum unless shown otherwise on the PLANS, engraved through the face layer to the melamine middle layer.
- d. Accessories: Provide holes for mechanical fastening
- e. Attachment Means: Secured with two Stainless Steel screws.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Minimum mounting height shall be 3-foot 6-inches above finished floor unless shown otherwise on the PLANS. Secure stations firmly to support channels as specified in Section 16150 "Raceways, Fittings and Supports".

### **3.02 FIELD TESTING**

- A. Perform field testing as required elsewhere.

### **3.03 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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## **SECTION 16550**

### **GROUNDING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Provide grounding in accordance with the PLANS, these Specifications and the National Electrical Code "N.E.C." Included within this section are furnishing and installing all the wire, connections, and other devices associated with the grounding system associated with the aforementioned.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

##### **1.03 SUBMITTALS**

- A. Submit shop drawings on all grounding system product and in accordance with Section 01300 of the Specifications. Include material safety data sheet for ground enhancement material.

#### **PART 2 PRODUCTS**

##### **2.01 GENERAL**

- A. Equipment and/or static voltage and/or any other ground buses/bars (for any other type of use) called for on the PLANS and Specifications shall be tin-plated copper.

#### **PART 3 EXECUTION**

##### **3.01 GENERAL:**

- A. Ground all electrical and instrumentation equipment, including lights, receptacles, instruments, etc., with a separate equipment ground wire installed in the conduit with the power conductors.
- B. Install grounding system electrically and mechanically continuous throughout. System neutral shall be bonded only at the building service transformer.

- C. Connect equipment grounding conductors to ground bars or busses provided at panelboards, motor control centers, disconnect switches, switchgears, etc., from which the equipment is served.
- D. Where the equipment has no facility to attach an equipment ground wire, use a Burndy Quicklug or equal. Clean the metal surface under the lug to bright metal so that good contact can be made. Repaint metal surfaces after the lug and connecting ground wires are installed.
- E. Make ground connections to equipment by using ground lugs or ground bars, where they are provided.
- F. Furnish bonding jumpers as shown or as otherwise required by the National Electrical Code "N.E.C." Use stranded copper wire.
- G. Inside buildings and at above ground level and through concrete floor slabs, route the ground wire(s) in a conduit raceway system. Fill annular space between ground wire and conduit with Crouse Hinds, Nelson or Raychem watertight and flame-retardant sealant.
- H. Connect ground wires entering outlet boxes in such a manner that removal of the receptacle will not interrupt the continuity of the grounding circuit. A grounding screw attached to the box, and used for no other purpose, may be used to accomplish this.
- I. After ground wire connections have been made to equipment, to instruments, to devices, etc., the Contractor shall apply "3M" 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal corrosion resistant and moisture repelling electrical coating/spray to all exposed wiring and all wire connections. Coordinate application with the Owner.
- J. Install a bonding jumper from the grounding lug of each Conduit-Grounding-Bushing to the ground bar or bus of each enclosure and/or equipment housing (such as pull boxes, junction boxes, panelboards, motor control centers, transformers, automatic transfer switches, instrument and control panels, etc.), as applicable. Instrument Grounds to be separate from power grounds. Instrument ground to be insulated up to the connection to the ground grid. Also refer to details shown on the Drawings. Bonding jumper wire for Conduit system Grounding-Bushings shall be STRANDED bare copper wire with minimum of 19-strands. Bonding jumper wire size as required by the National Electrical Code "N.E.C.", however, minimum wire size shall be #10 AWG.

### **3.02 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION



## **SECTION 16800**

### **CALIBRATION, TESTING AND SETTINGS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Provide all equipment and labor required for calibration, setting and testing as described herein or otherwise required. All tests shall be witnessed by the OWNER or the OWNER's designated representative. Give written notification of the tests at least seven days prior to the desired date to perform the tests. Repair or replace all defective material, equipment or workmanship disclosed as a result of these tests at no cost to OWNER.
- B. All work, including installation, connection, calibration, testing, and adjustment, shall be accomplished by qualified, experienced personnel working under continuous, competent supervision. The completed installation shall display competent work, reflecting adherence to prevailing industrial standards and methods.
- C. Tests: The Contractor shall make all tests required by these specifications, or other authorities having jurisdictions. All such tests shall be performed in the presence of the OWNER or the OWNER's designated representative. The Contractor shall furnish all necessary testing equipment and pay all costs of tests, including all replacement parts and labor necessary due to damage resulting from damaged equipment or from test and correction of faulty installation.

##### **1.02 SUBMITTALS**

- A. Submittals shall include copies of the test results/reports. Submittals shall be per the quantity and format requirements of Section 01300 and 01730 of the Specifications. Include the following at minimum:
  - 1. Test results, inclusive of catalog number/drawing cross-reference, where applicable, and any other data entered on the field test report
  - 2. Testing Plans
  - 3. All test instrument data sheets and calibration certificates

##### **1.03 TEST PLAN AND TEST RESULTS**

- A. Performance: Testing shall be performed in compliance with the approved Test Plan. The Test Plan shall be submitted in accordance with the outline given below. Provide the OWNER with typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, names of witnesses, weather conditions; and test values and results.
- B. Test plan: At minimum, Submit a Test Plan for each of the Sections listed in Division 16 of these specifications. Test Plan shall be submitted at least two (2) weeks prior to the desired date and time of the test. Test Plan shall clearly identify the following, as applicable:
  - 1. Desired date and time to perform the test

2. Name of Entity/individual that shall perform the test
3. Test procedures and recording data sheets
4. Name, description, catalog number, calibration date, and calibration entity's name of each of the test instruments to be used in executing the test
5. Expected duration of the test
6. Request for type, time and duration of any shutdown that may be required during the test.

C. Test Results:

Submit Test Results for each of the Sections listed in Division 16 of these specifications. Test Results shall be submitted no later than at least two (2) weeks after the last date of the respective test. Test Results shall be typewritten and shall include the following, as minimum:

1. All data and information provided in the Test Plan
2. Name of Entities and individuals that attended and witnessed the test
3. Weather Conditions
4. Tabulated test values and results
5. Corrective measures taken and/or to be taken toward defective material, equipment or workmanship disclosed as a result of these tests. Also include Re-Test dates and procedures for defective material, equipment or workmanship disclosed from the previous test.

#### **1.04 TEST EQUIPMENT**

- A. Each test instrument shall have been certified by an established calibration laboratory within the six (6) months prior to its use in testing and calibration procedures. Calibration shall be traceable to the National Institute of Standards and Technology (NIST).

### **PART 2 PRODUCTS**

- A. No products are required by this Section of the Specifications.

### **PART 3 EXECUTION**

#### **3.01 INSULATION RESISTANCE (MEGGER) TESTS:**

- A. Use a minimum 500 volt megohmmeter.
- B. Take each reading for at least one minute.

- C. Include the following tests:

<u>Equipment</u>	<u>Minimum Resistance</u>
115 and 230 volt motors	5.0 Megohms
460 volt motors	7.0 Megohms
600 volt transformer winding	100.0 Megohms
600 volt wiring up to 1000 ft.	25.0 Megohms

Coordinate minimum values shown with equipment manufacturer's recommendations.

- D. Test all transformer windings as follows:
1. Primary to ground
  2. Secondary to ground
  3. Primary to secondary
- E. Record and submit all Megger readings to the OWNER/ENGINEER for review and record keeping purposes. Neatly type all readings and organize in a Database table form. Incremental megger readings shall also be recorded and included in the table.
- F. Test medium voltage cables in accordance with Section 16182 "Medium Voltage Cables."

### **3.02 GROUND TEST**

- A. Ground System testing shall be performed by an independent professional testing company specialized in, and well equipped to perform, ground resistance testing.
- B. Ground testing shall assure resistance to ground values listed in the Grounding Specification. All tests must be witnessed by the Owner or the Owner's designated representative.
- C. At a minimum, test each of the following separately, with ground under test isolated from other grounds:
1. Each process area/building grounding network, i.e., Thickener Building, etc. Furnish and install additional grounding/ground electrodes if the resistance to ground measures more than the values stipulated in the Grounding Section of the Specifications. This shall be executed at no additional cost to the Owner.
  2. Each manhole,
  3. Each handhole,

- D. Finally, after all tests of each individual process area/building, manhole, handhole, etc., are performed as previously specified, perform a final test after all of the individual process areas/buildings, manholes, handholes, etc. grounding networks are interconnected as also shown on the PLANS.

### **3.03 MOTORS**

- A. Test the insulation resistance (megger test) of all motors installed under this Contract inclusive of process mechanical drive motors and the Heating and Ventilation System drive motors such as exhaust fans, fan and coil units drive motors, etc. Test all motors in accordance to with subsection 3.01 above.
- B. Dry out any wet insulation by use of space heaters or other approved methods.
- C. Check coupling alignment, shaft end play, lubrication, and other mechanical checks as required. Follow manufacturer's instructions.
- D. Check for proper motor rotation.

### **3.04 RECEPTACLES**

- A. Test all receptacles for proper connections and grounding. Use an approved plug-in tester equal to Woodhead 1750 or Hubbell 5200.

### **3.05 CONTROL CIRCUITS**

- A. Check all circuits for continuity, proper connection, and proper operations.
- B. Set all time delay relays and timers for the desired operations. Record the settings, indicating the relay or timer, its location, and the setting used. Verify all settings with a stopwatch.

### **3.06 CONTINUITY TESTS**

- A. Perform continuity test on all low voltage conductors (600 volt, and below, wiring system). Continuity test must be performed after wiring is pulled in the conduit system and/or underground electrical system (as applicable). Continuity test must be performed on each conductor between its source and final destination (point of termination to load/device/etc.). Utilize Ohmmeter for this test. Ohmmeter must be set to lowest ohm setting (highest resolution).

### **3.07 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

## SECTION 17100

### PROCESS INSTRUMENTATION AND CONTROL SYSTEMS (PICS)

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Provide all labor, materials, and equipment to design, furnish, install, calibrate, test, adjust, and place in operation the facility complete monitoring and control system as specified herein and as shown on the PLANS. The PLANS and Specifications show and specify those features required to illustrate and describe functional requirements of the monitoring and control system.
- B. A single Instrument and Control System Contractor (ICS) shall furnish all services and equipment defined herein and in other Specification sections as listed below under Related Work. The Instrument and Control System Contractor is referred to herein and after (in Division 17 of the Specifications) as the ICS, ICS supplier/firm, or Contractor. The ICS shall have the qualifications as described in subsection 2.0, "Quality Assurance", this Section of the Specifications.
- C. The ICS shall also:
  - 1. Terminate and tag all field wiring associated with the process instrumentation and control system shown on the PLANS and specified herein and in other Specification sections listed below under Related Work.
  - 2. Tag Instrumentation and control wiring/cable per the requirements and methodology/scheme outlined in specifications Section 16200 "Wiring (600 Volts and Below)" paragraph 3.03 "Wire Tagging Methodology".
  - 3. Calibrate, set and test the PICS equipment, components, cables, hardware, and software.
  - 4. For all PICS equipment and ancillaries, provide:
    - a. Required submittals.
    - b. Equipment and ancillaries.
    - c. Instructions, details, and recommendations to, and coordination with, all other installation entities for Certificate of Proper Installation.
    - d. Certifying readiness for operation.
    - e. Starting up.
    - f. Testing.
    - g. Training
    - h. Use of testing/calibration equipment to facilitate calibration/testing of field sensors and instruments. Equipment shall include, but not be limited to:
      - 1) Test pressure pump for field calibration/testing of pressure transmitters.
      - 2) Signal generator/multi-function meter for field calibration/testing of resistance temperature detector (RTD) monitoring devices
      - 3) Temperature/heat generator for field calibration/testing of temperature transmitters.
      - 4) Shaker table for vibration transmitters, etc.

5. Provide special additional services during installation, including:
    - a. Verifying that the following are furnished and installed:
      - 1) Correct type size, and number of signal wires with their raceways.
      - 2) Correct electrical power circuits and raceways.
      - 3) Correct size, type, and number of PICS related pipes, valves, fittings, and tubes.
      - 4) Correct size, type, materials, and connections of process mechanical piping for in-line primary elements
    - b. For equipment not provided by the ICS, but directly connected to the PICS:
      - 1) Obtain manufacturer's information regarding installation, interface, function, and adjustment for equipment from the Contractor.
      - 2) Coordinate with Contractor to allow required interface and operation with the PICS.
      - 3) Verify that installation, interfacing signal terminations, calibration, and adjustments have been completed in accordance with the manufacturer's recommendations.
      - 4) Test to demonstrate the required interface and operation with the PICS.
      - 5) Examples of equipment in this category include, but are not limited to the following:
        - a) OWNER's Top-End Computer System
        - b) Motorized Valve Operators
        - c) Motor Control Centers
        - d) Process/Mechanical Equipment
  6. Assist OWNER/ENGINEER, as specified in applicable DCS subsystem specifications sections, in the PAT testing of the Applications Software which shall be developed by OWNER/ENGINEER for the DCS (as applicable).
- D. The Distributed Control System at the Electrical Room of the Inlet Facility are networked with the OWNER's existing plant Top-End computer system by means of DCS equipment at the OWNER's existing Control Panels. Effort is required of the ICS to maintain a functional and complete communication network links between the proposed equipment of this project and the Owner's existing DCS equipment in order to achieve proper and complete system operation. This effort shall include, but not be limited to:
1. Coordination with all responsible parties, i.e. OWNER, manufacturers, etc., to facilitate proper cable termination, locations in controls panels, etc., as required
  2. System startup testing, diagnosing, and resolving communication system issues, etc.
- E. Extensive field verification is required for all modifications to existing control panels. The ICS shall include effort associated with field verifying spatial dimensions inside the existing control panels for proposed equipment, wiring terminations, loop power supply sizes, loads on existing instrument loops, points of connections to existing equipment, etc. as required to support the proposed modification effort associated with this project. The ICS shall field locate proposed equipment to be installed inside the existing control panel as also shown on the PLANS. The proposed location shall be coordinated with the arrangement of the existing control panel internal and externally mounted components.

- F. The OWNER's existing distributed control system is vital to the OWNER's treatment plant process system. Therefore, required interruptions to the OWNER's existing distributed control system shall be minimized and coordinated with the OWNER. Should an outage to a facility be required, the Contractor shall request such an outage in writing no less than ninety-six (96) hours in advance. Contractor's written request shall identify the desired date, time, duration, and purpose of the requested day unless he/she obtains a written approval from the owner authorizing the outage. The OWNER reserves the right to modify or reject any request such an outage. Modification or rejection of the contractors request be the OWNER shall not be considered reason for delays in the construction schedule. Unless otherwise noted, the duration of the outage shall be limited to four (4) hours or less. The OWNER reserves the right to limit the duration of the outage to less than 4 hours. Modification of the outage duration by the OWNER shall not be considered reason for delays in the construction schedule.
- G. The OWNER's existing distributed control system equipment and its associated interconnect wiring, power supplies, fuses, etc., is in perfect working condition. Should the existing equipment, its associated interconnect wiring, power supplies, fuses, etc., as applicable, be damaged or become otherwise unusable during the construction course of this project, the ICS shall determine the problem, correct it, and furnish and install all necessary wiring/hardware/etc., to match existing and make all final connections such that all affected equipment operates as previously operated to the OWNER's satisfaction at No Additional Cost to the OWNER.

## **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Division-16 ELECTRICAL SPECIFICATIONS
- D. Division-17: INSTRUMENTATION AND CONTROL SPECIFICATIONS
- E. All other divisions of the Specifications related to the installation of the process mechanical equipment, etc. that are related to the operation of the instrumentation and control system.
- F. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

## **1.03 SUBMITTALS**

- A. General: Do not design, manufacture, or ship any PICS equipment until all related submittals have been reviewed and approved by the ENGINEER. Submit shop drawings and product data in complete functional packages; i.e., submit all shop drawings and product data for a given loop or subsystem together as a functional package. Piecemeal submittals not organized by systems or incomplete submittals for a given loop or subsystem will not be accepted.

- B. Administrative Submittals:
1. Schedule of Values
    - a. Purpose: Project Schedule of Values to provide a basis for Partial Payment for Work completed.
    - b. Content: Summary of major milestones and associated Partial Payments for Work provided under PICS Subsystems.
  2. PICS Progress schedule
    - a. Purpose: Supplement the overall Project Progress Schedule to:
      - 1) Coordinate activities between the Contractor and the ICS
      - 2) Coordinate interactions with the OWNER/ENGINEER for coordination meetings, submittal reviews, etc.
      - 3) Clarify required work sequences and major milestone prerequisites.
    - b. Provide multiple submittals of the project schedule throughout the duration of the Project as required.
  3. OWNER Training Plan: Submit description/schedule of OWNER Training to be provided.
  4. Statements of Qualification: Submit for PICS firm, site representative, start-up and testing team member.
- C. Submit shop drawings in accordance with Section 01300 of the Specifications and as specified below:
1. Detailed product data, catalog cut sheets, cabinet exterior and interior front elevations, bill of materials, and spare parts list
  2. Point-to-Point Wiring Diagrams: Prepare Point-to-Point Instrument Loop Wiring Diagrams, ladder diagrams (control schematics), cabinet wiring, and other field wiring diagrams in accordance to the format shown on the PLANS. Drawings shall be neat, and legible, and on 11 inch x 17 inch sized sheets. Drawings to include all relevant information for equipment connected to the PICS, regardless if the equipment is provided by the ICS or not, i.e., include motor control centers, OWNER pre-purchased equipment, etc. where controls interconnection is required with the same. Contractor shall also submit for approval a complete schedule of all wire tag numbers sorted by area and equipment/instrument/field device.
  3. Although typical control schematics/instrument loops are presented on the PLANS for some equipment, the Contractor shall generate specific equipment control schematic drawings/instrument loops (i.e., individual control schematic/instrument loop drawings dedicated for each specific equipment) based upon the typical control schematic/instrument loop drawings, the device identification/tag replacement schedules shown on the PLANS, and the additional requirements described herein. The Contractor generated specific equipment control schematics/instrument loops shall follow the same overall presentation format as the typical equipment control schematics/instrument loops presented on the PLANS. The specific equipment control schematics/instrument loop drawings complete with all specific equipment/device tags (as a minimum, also refer to the additional requirements described herein) shall be generated by the Contractor and included with the project submittals (i.e., prior to equipment purchase) and the "As-Built" drawings. Any Contractor generated control schematic/instrument loop shown as applicable for multiple equipment shall not be accepted.
  4. Contractor may submit wire tag samples for all types of interconnect and field wiring from the proposed/existing cabinets/panels with associated point-to-point wiring diagrams in a separate submittal for approval prior to submitting



the complete wire tag schedule for review. After approval of the sample wire tags, a wire tag table showing all provided wire tags shall be submitted for review with the associated point-to-point wiring diagrams. Refer to Specification 17100 Subsection 1.03.C.5 for additional wire tag table requirements. Refer to Specification 16200 Subsection 3.03 for wiring tagging methodology.

5. Wire Tags: Contractor shall also submit for approval a complete schedule of all wire tag numbers sorted by area and equipment/instrument/field device. It is anticipated that all wire numbers cannot be accommodated on the loop diagrams, ladder diagrams, control schematics, etc. format shown on the PLANS. As a minimum, to facilitate the depiction of the wire numbers on the loop diagrams, ladder diagrams, control schematics, etc., the Contractor shall generate and include uniquely identified alpha-numeric wire codes on the loop diagrams, ladder diagrams, control schematics, etc. The wire codes shall cross-reference tables of wire numbers shown on additional drawings that shall be generated by the Contractor. At minimum, the Contractor shall generate the wire codes and the cross-reference tables which depict the wire numbers associated with each wire code and shall group the cross-reference tables by specific equipment (Gate No. 1, Gate No. 2, Gate No. 3, etc.). As a minimum, the Contractor shall generate drawings to depict the wire code and wire tag cross-reference tables and these drawings shall also be grouped by specific equipment (Gate No. 1, Gate No. 2, Gate No. 3, etc.). Contractor shall submit wire tag samples for all types of interconnect and field wiring from the proposed/existing cabinets/panels with associated point-to-point wiring diagrams in a separate submittal for approval prior to submitting the complete wire tag schedule for review.

D. Testing Related Submittals:

1. Submit factory and field calibration reports
2. Submit the following for each of type of test (ORT and PAT) required under Division 17 of the Specifications:
  - a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
  - b. Final Test Procedures: Proposed test procedures, forms, and checklists.
  - c. Test Documentation: Copy of signed off test procedures when tests are completed.

E. Training Related Submittals:

1. Submit the following for each type of training required under Division 17 of the Specifications:
  - a. Training plan, course topics, subjects to be addressed in the training
  - b. Schedule
  - c. Training agenda for each course
  - d. Instructor qualifications
  - e. Listing of available training courses and outline of course topics and agendas

- F. Submit Operation and Maintenance manuals in accordance with Section 01300 and 01730 of the Specifications and as specified below:
  - 1. Include approved shop drawing data in the Operation and Maintenance manuals with the following modifications to the shop drawing exhibits:
    - a. Reflect "As-Built" conditions.
    - b. Prints of exhibits, wiring diagrams, etc. shall be half size (11 inch by 17 inch).
  - 2. Procedures for operating and shut-down
  - 3. Included approved Testing Related Submittals with final "As-Built" conditions.
  - 4. Safety instructions.
  - 5. Calibration instructions and factory test results of each instrument.
  - 6. Maintenance and repair instructions.
  - 7. Recommended spare parts list.
  - 8. Name, address and phone number of instrumentation control system supplier's local representative.
  - 9. Additionally, comply with the requirements of the Contract Documents.

#### **1.04 SPECIAL CONDITIONS**

- A. All components used in the instrument and control systems shall be new (not used) and the current model produced by the manufacturer.
- B. All equipment of a common type shall be the product of a single manufacturer.

### **PART 2 QUALITY ASSURANCE**

#### **2.01 ACCEPTABLE PROCESS INSTRUMENTATION AND CONTROL SYSTEM (PICS)**

- A. Provide a complete, workable, and installed-in-place Process Instrument and Control System, hereinafter referred to as the PICS, as specified herein. The PICS shall be designed, installed, and started up by the single ICS firm.
- B. Acceptable ICS firm shall have the following minimum qualifications:
  - 1. ICS Firm: Minimum of 5 years experience in providing, integrating, installing, testing, and start-up similar systems as those required for this project
  - 2. ICS Firm Site Representative: Minimum of 8 years experience installing similar systems as those required for this project
  - 3. ICS Firm Start-up and Testing Team Members: Minimum of 3 years experience in testing systems similar to those required for this project.
- C. PICS meetings to be scheduled in accordance with the Contract Documents.

#### **2.02 SYSTEM COORDINATION AND QUALITY**

- A. Coordinate installation of instrumentation with mechanical and electrical systems.
- B. Coordinate subsystems to provide a complete operational and functional instrumentation system to the satisfaction of the OWNER and ENGINEER.
- C. Equipment, instruments, components, and materials for PICS components shall be new (not used) and of the current model.

- D. Instrument and Control Components Furnished By Others: Certain items of instrumentation and controls shall be furnished by various equipment manufacturers. Coordinate the purchase orders of the items such that the resulting system will function properly.

## **2.03 DESIGN CRITERIA**

- A. Design, construct, and install all PICS components in compliance with the applicable provisions of the following standards, codes, and regulations:
  - 1. American National Standards Institute (ANSI) Standards.
  - 2. American Institute of Steel Construction (AISC) Standards.
  - 3. American Society for Testing and Materials (ASTM) Standards.
  - 4. American Waterworks Association (AWWA) Standards.
  - 5. Joint Industrial Council (JIC) Standards.
  - 6. National Electric Code (NEC)
  - 7. National Electrical Manufacturer's Association (NEMA) Standards.
  - 8. Local and State Building Codes.
  - 9. Occupational Safety and Health Administration (OSHA) Regulations.
  - 10. Scientific Apparatus Manufacturer's Association (SAMA) Standards.
  - 11. International Society of Automation (ISA) Standards.
  - 12. National Fire Protection Association (NFPA)
  - 13. Institute of Electrical and Electronics Engineers (IEEE).

## **2.04 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Delivery: Enclose cabinets and subassemblies in heavy polyethylene envelopes to protect them from dust and moisture. Place corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.
- B. Storage: All materials and equipment shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment. The Instrument Control Panels and the field control and instrument/monitoring panels shall not be moved from climate controlled storage room to the project site until the construction of each electrical/control room is completed, and, the air-conditioning and heating system of the facility is in an operating condition satisfactory to the OWNER and ENGINEER.

## **2.05 CALIBRATION INSTRUMENTS**

- A. Each instrument used for calibrating PICS equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous twelve (12) months to a standard endorsed by the National Institute of Standards and Technology (NIST). At OWNER's request, ICS shall submit calibration certification report.

## **2.06 START DATE OF THE PROCESS INSTRUMENTATION AND CONTROL SYSTEM AND ASSOCIATED SUBSYSTEM WARRANTY (PICS INCLUDING SUBSYSTEMS)**

- A. Start Date of the process instrumentation and control system and associated subsystem Warranty (PICS including Subsystems) shall commence the date in

which the Warranty period commences for the overall project per the requirements of the Procurement Documents.

## **PART 3 SEQUENCING AND SCHEDULING**

### **3.01 GENERAL**

- A. All work provided under this section shall be in accordance with the OWNER/ENGINEER-approved Schedule of Submittal Submissions and Schedule of Values.
- B. Specification and Construction Implementation Plan requires phased installation of equipment and systems. Stage all PICS activities (submittals, fabrication, installation, testing, start-up, training, etc.) to support the construction sequencing requirements of the project.
- C. Wherever language in this section refers to the PICS, the entire installed PICS, the entire PICS, or similar language, it shall be interpreted to apply to the individual phases of the work; except the requirements for the Performance Acceptance Test (PAT).
- D. Key milestone dates associated with PICS activity shall be included in the overall project schedule. Include the following dates as a minimum:
  - 1. ORT start and end date
  - 2. PAT start and end date
  - 3. Training dates

### **3.02 PREREQUISITE ACTIVITIES AND LEAD TIMES:**

- A. Start the following key Project activities when prerequisite activities and lead times listed below have been completed and satisfied:
  - 1. Test Prerequisite:
    - a. All associated process and mechanical equipment, controlled and monitored by the instrumentation and control system, complete in place
    - b. Associated test plan submittal completed. For ORT and PAT, notice of test schedule required 4 weeks prior to the start of test
  - 2. ORT Prerequisite:
    - a. Approved ORT test procedures
    - b. Approved ORT test forms
    - c. 30 calendar days advance written notice to given to OWNER of impending ORT.
  - 3. PAT Prerequisite:
    - a. ORT successfully completed.
    - b. Approved PAT test procedures
    - c. 30 calendar days advance written notice to given to OWNER of impending PAT.
  - 4. O&M submittal prerequisite: PAT successfully completed.

## **PART 4 PRODUCTS**

### **4.01 GENERAL**

Refer to requirements of PICS Subsystem provided in Division-17 Specifications.

### **4.02 SOURCE QUALITY CONTROL**

#### **A. General:**

1. Test all PICS elements, both hardware and specific software, to demonstrate that PICS satisfies all requirements.
2. On-Site Tests Described Under PART 5 - EXECUTION:
  - a. Operational Readiness Test "ORT"
  - b. Performance Acceptance Tests "PAT".
3. Test Format: Cause and effect
  - a. Person conducting test initiates an input (cause)
  - b. Specific test requirement is satisfied if the correct result (effect) occurs
4. Procedures, Forms, and Checklists:
  - a. Conduct all tests in accordance with, and documented on, ENGINEER accepted procedures, forms, and checklists.
  - b. Describe each test item to be performed.
  - c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
5. Required Test Documentation: Test procedures, forms, and checklists. All signed by OWNER/ENGINEER and Contractor.
6. Conducting Tests:
  - a. All special testing materials and equipment.
  - b. Wherever possible, perform tests using actual process variables, equipment, and data.
  - c. If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
  - d. Define simulation techniques in test procedures
  - e. For PICS Subsystems for which OWNER provides applications software, provide sufficient temporary software configuring to allow for ORT testing of these subsystems.
7. OWNER/ENGINEER will actively participate in many of the tests.
8. OWNER/ENGINEER reserves the right to test or retest all specified functions whether or not explicitly stated in the Test Procedures.
9. OWNER's/ENGINEER's decision will be final regarding acceptability and completeness of all testing.

- #### **B. Provide field support during OWNER/Engineer testing of installed applications software**

## **PART 5 EXECUTION**

### **5.01 EXAMINATION**

- #### **A. Equipment furnished by Supplier or any other subcontractor and installed by the ICS/Contractor, requires Supplier to observe and advise on installation to extent required to certify that equipment has been properly installed and will perform as required.**

- B. For equipment not provided by the ICS, but that directly interfaces with the PICS, verify the following conditions:
  - 1. Proper installation.
  - 2. Calibration and adjustment of all instrumentation and control devices.
  - 3. Correct control action.
  - 4. Switch settings.
  - 5. Opening and closing speeds and travel stops.
  - 6. Input and output signals.

## **5.02 INSTALLATION**

- A. Material and Equipment Installation:
  - 1. Follow manufacturer's installation instructions, unless otherwise indicated or directed by the OWNER/ENGINEER
  - 2. Retain a copy of the manufacturer's instructions at the project site, available for review at all times.
- B. Wiring:
  - 1. All wiring connected to PICS components and assemblies shall be in accordance to the requirements of Division 16 and 17 of the Specifications.

## **5.03 FIELD QUALITY CONTROL**

- A. General: All requirements listed in Subsection Source Quality Control, above, also apply to this Subsection, Field Quality Control.
- B. Onsite Supervision:
  - 1. The ICS Project Site Representative shall supervise and coordinate all onsite PICS activities.
  - 2. The ICS Project Site Representative shall be On-Site during total period required to complete all On-Site PICS activities.
- C. Startup and Testing Team:
  - 1. Thoroughly check installation, termination, and adjustment for all PICS Subsystems and their components.
  - 2. Completed On-Site tests.
  - 3. Provide and conduct startup services
  - 4. Complete onsite training.
- D. Sequence of Work: Provide individual ORTs and PATs for individual process equipment where required to support the staged construction and startup of the facility. Coordinate the construction sequencing requirements with the OWNER.
- E. Specialty Equipment: For certain components or systems provided under this Section but not manufactured by the ICS, provide services of qualified manufacturer's representative during installation, start-up, testing (both ORT and PAT) and OWNER's training. For example: RTD calibrator, vibration shaker table (which may be furnished/operated by vibration sensor manufacturer representative), pressure calibrator, etc, shall be provided as required.

F. Operational Readiness Test (ORT):

1. Prior to start of the Performance Acceptance Test "PAT", the ICS firm shall inspect, test the PICS equipment and systems, document the resulting tests performed, implement all corrective actions necessary, perform all associated re-testing, and document that the PICS is installed and ready for operation. Subsequent to the ICS documentation that the PICS is installed and ready for operation, perform jointly with the OWNER an ORT on the associated PICS equipment to demonstrate that it is fully operable as required by the Contract Documents.
2. For PICS subsystems where the PLC application software is provided by the OWNER, provide sufficient temporary software configuring to allow testing of these subsystems.
3. Loop/Component Inspections and Tests:
  - a. Check PICS for proper installation, calibration, and adjustment on a loop-by-loop, and component-by-component basis.
  - b. Develop and provide forms as required to document ORT. All forms generated shall have provisions for signature by PICS representative.
  - c. Develop and provide test form hereinafter called the "Loop Status Report" to organize, track inspection, adjustment, and calibration of each loop. Loop Status Report shall include the following as a minimum:
    - 1) Project name
    - 2) Loop number
    - 3) Tag number for each component
    - 4) Checkoff/signoffs for each component:
      - a) Tag/identification
      - b) Installation
      - c) Wiring termination
      - d) Tubing termination
      - e) Calibration/adjustment
    - 5) Checkoffs/signoffs for each loop:
      - a) Panel interface termination
      - b) PLC I/O interface terminations
    - 6) PLC I/O Signals are Operational: Received/sent, processed, adjusted
    - 7) Total loop operational
    - 8) Space for comments.
  - d. Develop and provide test form hereinafter called the "Component Calibration Sheet" to organize, track inspection, adjustment, and calibration of each component (except hand switches, pilot lights, gauges, and similar items) and each PLCs I/O Module. The Component Calibration Sheet shall include the following as a minimum:
    - 1) Project Name
    - 2) Loop Number
    - 3) Component tag number or I/O module number
    - 4) Manufacturer name
    - 5) Model number/serial number
    - 6) Summary of functional requirements. For example:
      - a) Indicators
      - b) Transmitters/converters, input and output ranges
      - c) Computing elements' functions
      - d) Controllers, action (direct/reverse) and control modes (P&ID)

- e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual)
      - f) PLC I/O modules: input or output
    - 7) Calibrations, for example, but not limited to:
      - a) Analog devices: Actual inputs and output at 0, 25, 50, 75, and 100 percent of span, rising and falling
      - b) Discrete Devices: Actual trip points and rest points
      - c) Controllers: Mode settings (P&ID)
      - d) PLC I/O Modules: Actual inputs or outputs of 0, 25, 50, 75, and 100 percent of span, rising and falling.
    - 8) Space for comments
  - e. Maintain loop status reports, valve adjustment sheets, and component calibration sheets at the project site and make them available to the OWNER at all times.
  - f. These inspections and tests, inclusive of the above described forms, will be spot checked by the OWNER.
  - g. The ICS shall implement all corrective measures needed and perform re-test on any modified sub-system/component.
  - h. The Contractor shall claim and validate a thorough ORT was performed successfully and all resulting corrective action measures taken were performed successfully and re-tested successfully. Upon successful completion of the ORT, the Contractor shall submit letter notification to the OWNER stating that the ORT has been successfully completed. The letter notification shall further state that the ICS is ready to begin the Performance Acceptance Test. Submit all forms upon completion of ORT as required by the OWNER.
- G. Performance Acceptance Tests "PAT":
1. Once the ORT has been successfully completed, perform jointly with the OWNER a PAT on the associated PICS to demonstrate that it is operating as required by the Contract Documents. The PAT will employ the OWNER's PLC application software developed for the project.
  2. Minimum duration of the PAT shall be a cumulative total of ten (10) calendar days. The cumulative total quantity of calendar days shall be consumed in association and in synch with the overall construction sequence for the project. Any Holidays that occur during the PAT shall result in a corresponding number of days being added to the duration of the PAT. The PAT encompasses startup and testing period of the instrumentation and control system for the associated process and mechanical equipment that are controlled and monitored by the instrumentation and control system. The PAT shall be conducted using application software developed by the Engineer. The ICS shall test functions installed and the hard-wired system and the entire associated instrumentation and control system including validating the operation and monitoring and control functions of the all instruments, all control devices, all instrument and control components, control functions, alarm function, monitoring function, calibration ranges, control/alarm setpoint operations, etc. OWNER/Engineer shall test software functions. The ICS shall also test the DCS.
  3. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis based upon the operating description used by the OWNER for PLC application software development.



4. Non-loop specific tests shall be the same as previously required except that the entire installed PICS shall be tested using actual process variables and all functions demonstrated.
5. Perform local and manual tests for each loop before proceeding to remote and automatic modes
6. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by Others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
7. Make updated versions of documentation required for PAT available to the OWNER at the project site, both before and during tests.
8. Develop and provide PAT test forms that include the following, at minimum:
  - a. Project name
  - b. Lists the requirements of the loop
  - c. Briefly describes the test
  - d. Cites the expected results and the actual results
  - e. Provides space for checkoff by witnesses.
9. Make one copy of all O&M manuals available to the OWNER at the site both before and during testing.
10. The ICS shall implement all corrective measures needed and perform re-test on any modified system.

#### **5.04 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

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## **SECTION 17200**

### **INSTRUMENTATION AND CONTROL CABINETS AND ASSOCIATED EQUIPMENT**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Furnish, install, and put into satisfactory service the modifications to the Owner's existing Main Instrumentation/Control Panels and/or Distributed Control System Panels as specified herein and as shown on the Drawings.
- B. The requirements of this Section of the Specifications applies to all of the various types of instrumentation and control cabinets/boxes as specified herein and shown on the PLANS.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

##### **1.03 SUBMITTALS**

- A. Submit the following in accordance with the Section 01300 and 01730 of the Specifications:
  - 1. Shop drawings and product data.
  - 2. Operation and maintenance manuals.

##### **1.04 TOOLS AND SPARE PARTS**

- A. Furnish the following spare parts in conformance with the specifications:
  - 1. One set (minimum 3) of fuses for each type and size used.
  - 2. One set (minimum 3) of Circuit Breaker Overcurrent Protection Devices for each type and size used.
  - 3. Ten (10) terminal blocks of each color and type used.
  - 4. One (1) control relay assembly of each type used, complete with all accessories.
  - 5. One (1) timing relay assembly of each type used, complete with all accessories.
  - 6. One (1) process variable transmitter Indicator controller, complete with all accessories.
  - 7. 25 percent spare push-buttons, selector switches, indication light assemblies for each type used (minimum of 1 per type).

8. 50 percent of spare lenses and lamps for each type, color and size used (minimum of 1 per type)

## PART 2 PRODUCTS

### 2.01 INSTRUMENT AND CONTROL WIRING

- A. General wiring and control power and alarm wiring:
1. Extra flexible, #14 AWG, tin plated copper conductor 600V insulation, SIS wire manufactured by General Cable Company, The Okonite Company or approved equal. The pigmentation of the wire insulation shall conform to the color table listed below:

<u>Wiring Function</u>	<u>Wire Jacket Color</u>
Wiring for 120 volts A.C. control/status signal wiring. This does not apply to control/status signal wiring that are scheduled for interface with Programmable Logic Controller (PLC) and Alarm wiring	Red
Wiring for 120 volts A.C. control to relay coils (L1 & L2 terminals or H&N terminals) that are not generated from a PLC Discrete Output point (DO)	Gray
Wiring for 120 volts A.C. power to instrumentation and control devices that are not generated from a PLC Discrete Output point (DO)	Gray
Alarm wiring	Yellow
Wiring for 24 volts D.C. power supply wiring	Blue = Positive Brown = Negative
Wiring for 120 volts A.C. light fixtures, convenience receptacles and exhaust fans	Red = Line (Phase A) Black = Line (Phase B) Blue = Line (Phase C) White = Neutral
Wiring to Discrete Input PLC modules	Violet
Wiring to Discrete Output PLC modules	Pink
Ground wires	Green

- B. 4-20 Milliamp Signal wiring:
1. Number of Pairs: One
  2. Wire Size: #16 AWG
  3. Type of Conductors: Stranded copper conductors, twisted

4. Individual Conductor Insulation: PVC
5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White
6. Drain Wire: Tinned copper
7. Overall Shield: Aluminum-mylar shield.
8. Overall Jacket: PVC
9. Overall Jack Color: Black.
10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1852 or approved equal.

## **2.02 INSTRUMENT AND CONTROL CABINETS EQUIPMENT**

- A. Overcurrent Protection
  1. General: Individually protect each device as shown on the PLANS. Furnish and install protection using the devices shown on the PLANS and as specified hereinafter.
  2. 120 volts AC circuit Protective Devices:
    - a. Ratings: 120 volts A. C., one pole. Size per NEC. Note: Use 20 ampere rating for control panel convenience receptacles.
    - b. Certifications: U. L. Listed.
    - c. Mounting: Din Rail Mountable
    - d. Indications: Visible trip indicator
    - e. Manufacturer: Allen-Bradley Series 1492-SP, Phoenix Contact, or approved equal.
  3. 24 volts DC circuit breakers:
    - a. Ratings: 24 volts DC, one pole. Size per NEC.
    - b. Certifications: U. L. Listed
    - c. Mounting: DIN rail mountable
    - d. Indications: Visible trip indicator
    - e. Manufacturer: Allen-Bradley Series 1492-GH, Phoenix Contact, or approved equal.
- B. Pushbuttons, Selector Switches, Pilot Lights
  1. General Requirements:
    - a. Rating: NEMA 4X corrosion resistant, Heavy Duty
    - b. Size: NEMA Style full size 30-millimeter (30mm),
    - c. Contacts: 10 ampere minimum at 120 volts A.C. Provide number of contacts to satisfy the requirements of the PLANS.
    - d. Legend Plate: Furnish and install per manufacturer's standard with inscription as shown on the PLANS.
    - e. Manufacturer: Allen Bradley Bulletin 800H, or approved equal.
  2. Additional Requirements for Selector Switch/ Pushbuttons:
    - a. Operator Color: Furnish and install the color as shown on the PLANS, black otherwise.
    - b. Selector Switch Action Type: Maintained action, unless shown otherwise on the PLANS.
    - c. Pushbutton Action Type: Momentary action, unless shown otherwise on the PLANS.
  3. Additional Requirements for Pilot Lights:
    - a. Type: Transformer Type Light Emitting Diode (LED),
    - b. Style: Push-to-test
    - c. Lens Color: Furnish and install the colors as shown on the PLANS.

4. Additional requirements for Emergency Stop/Trip Push-Button Stations:
  - a. Action Type: Push-Pull maintained
  - b. Operator Type: Mushroom head
  - c. Operator Color: Red, unless shown otherwise on the PLANS
  - d. Padlock attachment: Furnish and install as manufactured by Allen-Bradley Bulletin Push-Pull Padlocking Attachment Catalog Number 800T-N314, or approved equal.
  - e. Padlock: Furnish and install padlock with 0.25 inch diameter padlock shackle. Coordinate the shackle diameter with the padlock attachment. Furnish and install padlock as manufactured by Master Lock, or approved equal.
- C. Control Relays: Control relays shall be furnished and installed as required by the schematic diagrams. All control relays shall be Type I relays unless specifically noted otherwise on the PLANS or as specified hereinafter.
  1. Type I Control Relays:
    - a. Type: 300 volt "Ice-Cube" type
    - b. Rated: Pilot-Duty C300 rated
    - c. Coil Voltage: 120 volts A.C.
    - d. Contact Rating: 10 ampere at 120 volts A.C.
    - e. Number and Configuration of Contacts: three Form-C Contacts (3PDT)
    - f. Position Indication: Integral LED pilot light
    - g. Manual Operator: Integral to relay
    - h. Mounting: DIN rail mountable socket
    - i. Accessories: Socket, Retaining Clip, Relay Manufacturer's Transient Voltage Suppression Module.
    - j. Manufacturer: "Allen-Bradley" Bulletin 700-HA33A1-3-4, complete with 700-HN205 socket, 700-AV3R surge suppressor, and 700-HN157 retainer clip, or approved equal.
    - k. The following are additional requirements associated with Type I control relays:
      - 1) Of the maximum of three Form-C type contacts that are available from each Type I Control Relay, one of the Form-C contacts shall be dedicated as "spare" and wired to terminal blocks for future use by the OWNER. Multiple Type I relay coils shall not be connected in parallel in order to develop additional contacts as may be shown on the PLANS. Should the PLANS require greater than two contacts from a control relay, then furnish and install a Type II Control Relay in lieu of a Type I Control Relay.
  2. Type II Control Relays:
    - a. Type: 600 volt Heavy-Duty industrial type
    - b. Rated: NEMA rated
    - c. Coil Voltage: 120 volts A.C.
    - d. Contact Rating: 10 ampere at 120 volts A.C.
    - e. Number and Configuration of Contacts: 4 Normally Open and 4 Normally Closed, at minimum. Furnish and install one additional normally open (N.O.) and one additional normally closed (N.C.) contact, over that required by the PLANS. Field configurable type contacts.
    - f. Position Indication: Visual mechanical unlatch-latch indicator
    - g. Mounting: Provide universal mounting strip/plate for backpanel mounting.
    - h. Accessories: Relay Manufacturer's Transient Voltage Suppression Module

- i. Manufacturer: Allen Bradley Bulletin 700-P, or approved equal.
3. Type III Control Relays:
  - a. Type: 300 volt "Ice-Cube" type
  - b. Coil Voltage: 24 volts D.C. (nominal voltage)
  - c. Position Indication: Integral LED pilot light
  - d. Manual Operator: Integral to relay
  - e. Contact Rating: 10 ampere at 120 volts A.C.
  - f. Number and Configuration of Contacts: four (4) Form-C Contacts (4PDT)
  - g. Mounting: DIN rail mountable socket
  - h. Accessories: LED indicator light, Push-to-Test button, socket and retaining clip
  - i. Miscellaneous: Used only where specifically noted on the DRAWINGS.
  - j. Manufacturer: "Allen-Bradley", catalog 700-HF34Z24-3-4, complete with relay socket base catalog number 700-HN139 and relay retaining clip 700-HN140, or approved equal.

D. Timing Relays:

1. Type: Solid state, multi-time, and multi-function type relay. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes: On Delay, Off Delay, One Shot, Repeat Cycle, and Interval
2. Coil Voltage: 120 volts A. C.
3. Contact Rating: 10 amps, continuous, at 120 VAC.
4. Number and Configuration of Contacts: 2 Form C (2PDT)
5. Mounting: DIN rail mountable socket
6. Accessories: Socket, DIN rail mountable
7. Manufacturer: Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

E. Terminal Blocks:

1. Type: Single Layer
2. Rating: 600 volts A.C./D.C., 55 ampere
3. Wire Range: No. 22 through No. 8 AWG
4. Material: Nylon or polypropylene
5. Quantity per Foot: 37
6. Terminal Block Colors: Provide terminal blocks with the colors as follows:

Terminal Block Function	Terminal Block Color
Terminal Blocks for 120 volts A.C. control/status/alarm/ PLC monitoring	Red
Terminal Blocks for 120 volts A.C. power wiring	Black
Terminal Blocks for Ground wiring	Green
Terminal Blocks for 24 volts D.C. wiring	White

7. Manufacturer: Allen-Bradley Bulletin 1492-HM3, Phoenix Contact, or approved equal.
8. Accessories:
  - a. All terminal blocks shall be provided with manufacturer's standard snap-in marker card and holder as manufactured by Allen-Bradley Bulletin No.

- 1492-SMN81, Phoenix Contact, or approved equal. Provide manufacturer's standard typed adhesive terminal block tag for each terminal block.
- b. Provide manufacturer's standard insulating jumpers, DIN rail, barriers, end anchors, etc., and all related mounting hardware as required for a complete and functional installation. Coordinate models of terminal block accessories such as end anchors, jumpers, DIN rail, etc., with the terminal blocks as specified hereinafter for a complete and functional installation.
- F. Flexible spiral wrapping: Size as required. Provide as manufactured by Electrovert Spiraband, or approved equal.
- G. Plastic Wireway: Size as required. Also refer to the PLANS. Provide white color unless specified otherwise. Provide as manufactured by Panduit, or approved equal.

## 2.03 IDENTIFICATION

### A. Instrument and Control Devices Identification

1. General:
  - a. The device designations shall agree with those shown on the PLANS.
  - b. Each device shall be provided with permanent type identifying nameplate.
  - c. Nameplates:
    - 1) Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
    - 2) Color: White-Black-White, unless shown otherwise on the PLANS.
    - 3) Lettering: 1/4 inch height minimum unless shown otherwise on the PLANS, engraved through the face layer to the melamine middle layer.
    - 4) Accessories: Provide holes for mechanical fastening.
2. Devices located on the face of, on the back, or inside of instrument control cabinets/panels:
  - a. Devices which penetrate the door shall be provided with two nameplates, one located on face of the door and one located on the rear of the door.
  - b. Nameplates located on the panels/cabinets face shall be secured with two Type 316-Stainless Steel screws.
3. Field mounted control and instrument devices:
  - a. Securely hang nameplates from each instrument/control device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).

### B. Wire Tag:

1. Rating: Flame-Retardant,
2. Style: Heavy-Duty Industrial Grade
3. Type: Heat Shrinkable type.
4. Character Height: 1/8 inch.
5. Maximum Length: 2 inches.
6. Text Type: Typed with indelible marking process. Handwritten shall not be accepted.



7. Color: Yellow. Exception: Use White for 120 volts A.C. power circuits to instrument/devices, and branch circuit lighting and convenience receptacle circuits.
8. Manufacturer: "Raychem type Heavy-Duty Industrial Grade ShrinkMark Heat-Shrinkable Marking Sleeves", or approved equal. Utilize "Raychem" Portable-Marking-System" complete with wire tag cartridges, or approved equal.

## **2.04 MISCELLANEOUS**

- A. Corrosion Resistant and Moisture Repelling Electrical Coating/Spray:
  1. Color: Clear. Coordinate spray color with the Owner. Furnish and install the color requested by the Owner at No Additional Cost to the Owner.
  2. Type: Corrosion resistant and moisture repellant fast drying spray coating sealant
  3. Manufacturer: "3M" 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal.

## **PART 3 EXECUTION**

### **3.01 STORAGE**

- A. Storage: Refer to Section 17100.

### **3.02 PANEL ASSEMBLY**

- A. All panel internal wiring, device installation, tagging, etc. shall be accomplished by the ICS at the site. All wiring shall be connected as shown on PLANS. Additional requirements are as described below.
- B. Termination and Routing of Wiring:
  1. Prior to being connected to any instrument or switch, all incoming wiring shall be terminated to terminal blocks located on an interior panel.
  2. Each PLC shall have dedicated terminal strips for each analog input, analog output, discrete input, and discrete output module, with each point from each module wired out and terminated to terminal blocks i.e., all input/output module points, where shown active or as spare, shall be wired out and terminated to terminal blocks. Spare points shall be treated the same as any other active point and shall follow the same format described under wiring/terminal block tagging scheme/strategy/method. Also refer to and comply with the requirements of the PLANS.
  3. Provide separate terminal blocks for power wiring, from control/discrete signal wiring, and from analog/instrument wiring. Additionally, segregate and isolate analog/instrument terminal strips from control/discrete signal wiring terminal strips from power wiring terminal strips.
  4. Terminate shield wire of each shielded cable to a terminal point (block) on the terminal strip (i.e., treat as current carrying conductor), with each shield terminated to a dedicated terminal block. Extend No. 14 AWG insulated green ground wire from each shielded cable shield termination terminal point to the isolated main ground bar of the cabinet (shield/drain wire ground).

5. Wire spare contacts of each device (i.e., control relays, timing relays, selector switches, indicating/controlling instruments/devices, etc.) to terminal blocks for future use by the OWNER.
6. Tag each terminal block. All tags must be typed and neatly attached to the marking surface.
7. Tag each terminal strip/string of terminal blocks with nameplates as previously specified.
8. Terminal blocks shall have the colors previously specified according to the function of the terminal block.
9. Utilize manufacturer's standard terminal block insulated side jumpers for making connections between adjacent terminal blocks.
10. Route all wiring from a device (instrument, relay contact, push button, etc.) through the terminal block to the other device (instrument, relay contact, push button, etc.) rather than directly from one device to the other.
11. All wiring shall be neatly bundled, laced together and routed as required throughout the cabinet. Enclose wiring routed against the back panel in plastic wireways where possible. Otherwise, group where possible and wrap with flexible wire wrapping or waxed twine. Wiring routed on doors shall be routed such that the door can be fully opened without stressing the wiring.
12. Wire entering the cabinets shall enter through the floor, the side and/or the top of the cabinets via conduits with bushings or hubs.
13. Also refer to and comply with the requirements of the PLANS.

C. Wire Tagging

1. Tag each wire at each end.
2. Tag each wire in multi-conductor cable in addition to the overall cable.
3. Heat shrink all wire tags.
4. Wire Tag Content:
  - a. Wiring of each equipment (such as Distribution Service Pump, Pump Discharge Control Valve, etc.) within the facility must be tagged different from any other equipment
  - b. Terminal block terminal designation must be included in the wire tag.
  - c. To represent all of the text to be shown, multiple wire tags may be needed at each end of the wire. Provide additional tags as necessary at no additional cost to the OWNER.
  - d. Provide per Section 16200 "Wiring (600 volt and Below), subsection 3.03 "Wire Tagging Methodology".

D. After all wiring connections have been made, the Contractor shall apply the Corrosion Resistant and Moisture Repelling Electrical Coating/Spray to all wiring connections. Coordinate application with the Owner. The extent of spray application is further clarified as follows:

1. Spray shall be applied for all terminations of the following types of connections at a minimum:
  - a. termination points, terminals, terminal blocks, ground bar, neutral bar/bus,
  - b. lugs of circuit breakers, buses, doors, etc.
  - c. exposed/stripped ends of each conductor, etc.
  - d. bolt-on connections, split-bolt connections, ring lugs, etc.
  - e. compression connectors, connector blocks, etc.
  - f. all other connection types not listed above

2. Spray shall be applied for all terminations at the following types of equipment at a minimum:
  - a. Local and main control panels, field instruments, junction boxes, field control stations, control relays, signal isolators, selector switches, pushbuttons, etc.,
  - b. Panelboards, transformers, motor control centers, manual motor starters, contactors, light switches, light fixtures, etc.
  - c. Motor termination enclosures, valve actuators, cathodic protection system, package control panels of process equipment, etc.
  - d. Security system devices, cameras, roadway gate operators, etc.
  - e. Convenience receptacles, scada receptacles, etc.
  - f. All other types of equipment not listed above.

### **3.03 FIELD INSTALLATION**

- A. All wiring shall be connected as shown on PLANS and all systems shall be thoroughly checked out.
- B. Install all equipment in accordance with the drawings and instructions furnished by the manufacturer.
- C. Inspect each new instrument, control component, etc., before installation. Replace deficient items.
- D. Touch-up and restore damaged surfaces to factory finish to match existing.

### **3.04 INSTALLATION REPORT**

- A. After installation, the manufacturer's representatives shall inspect the installation and prepare a report or reports to include the following:
  1. A list of all deficiencies found.
  2. Recommend corrective action for all deficiencies.
  3. Certification that the item or system is properly installed, except as noted.

### **3.05 FIELD CALIBRATION AND TESTING**

- A. Calibrate instruments and prepare calibration reports. All calibration shall be performed by factory-trained technical personnel. Calibration shall be witnessed by OWNER.
- B. The complete system shall be tested by an experienced factory-trained technical person. All system tests shall be witnessed by OWNER.
- C. Perform the following tests using simulated inputs:
  1. Check the overall system and each subsystem to see that they function as specified based on simulated inputs at each sensor and at each set of field contacts monitored. This check shall include the testing of all automatic functions, sounding of alarms, shutdowns, etc.
  2. Check the overall accuracy of each new and modified instrument loop to ensure that it is within acceptable tolerance.
- D. If defects are found under simulated conditions, make corrections and retest.

- E. After start-up, test the complete system under actual conditions to determine that all specified functions can be performed.
- F. After completion of testing, submit a System Test Report. This report shall include:
  - 1. Certification that the system is operating correctly and within tolerances.
  - 2. Listing of calculated tolerances for each new and modified instrument loop.

### **3.06 OPERATION AND MAINTENANCE TRAINING**

- A. Start-up Training: Provide required instruction to the OWNER's personnel during start-up period.
- B. Special Training School: Provide services of a factory-trained instructor or instructors for a period of not less than one (1) working day for the purpose of instructing the OWNER's personnel in the correct operating and maintenance procedures for all the instrument and hard-wired control system components installed in this project. The date of this school shall be scheduled with the OWNER, but will be after the entire instrument and control system is in operation.

### **3.07 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

## **SECTION 17380**

### **FIELD INSTRUMENTATION AND SENSING DEVICES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. The work performed under this Section consists of furnishing, installing, calibrating and placing into satisfactory service the following field mounted devices as specified hereinafter:
  - 1. Intelligent Pressure Measuring Indicators/Transmitters
  - 2. Digital Indicator
  - 3. Tubing, Hand Valves and Fittings
  - 4. Instrument Hoods (Sun Shields)
- B. Instrument Type Code:
  - 1. An Instrument Type Code identifies each instrument and consists of an alphabetical character(s) followed by three numeral characters.
    - a. Example Instrument Type Code: "A123".
  - 2. The Type Code serves as a means to reference each instrument in the specifications.

##### **1.02 RELATED REQUIREMENTS**

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

##### **1.03 SUBMITTALS**

- A. Submit the following in accordance with the Section 01300 and 01730 of the Specifications and in accordance to Section 17100 of the Specifications:
  - 1. Shop Drawings and product data.
  - 2. Submit wiring schematics for all equipment.
  - 3. Submit listing of all field instruments tag numbers for verification by OWNER.
  - 4. Test Reports: Completed and certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
    - a. Include factory calibration for each instrument with stated accuracy.
  - 5. Operation and maintenance manuals.
    - a. Include all completed and certified test reports in manuals.
      - 1) Refer to specifications herein for transmitter ambient and process fluid temperature ranges to be used for basis of accuracy analysis.
    - b. Include all programming setpoints and parameters for programmable instrument indicating transmitters/controllers.

6. Submit detailed listing of training class curriculum including, as a minimum, the following at least four (4) months prior to class:
  - a. Specific topics for each instrument, including but not limited to, general trouble-shooting, calibration, wiring, and general set-up/configuration.
  - b. Anticipated duration of class for each instrument type.
  - c. Names of instructor(s) for each specific instrument.
  - d. Refer to instrument by Instrument Type Code as listed in this specification section where applicable.

#### **1.04 QUALITY ASSURANCE**

- A. Standardization: All equipment of the same Instrument Type Code to be the product of a single manufacturer.
- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
  1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Material Compatibility:
  1. Material selections of instrument components noted in this section provide a basis for the minimum material compatibility requirements.
  2. Instrument component material selections shall be subject to additional restrictions and compliance with recommendations of instrument manufacturers for the intended service.
  3. Provide instrument component materials in compliance with specific process fluid temperature, pressure, chemical compatibility, and other process fluid parameters.

#### **1.05 TOOLS AND SPARE PARTS**

- A. Furnish the following spare Field Instrumentation and Sensing Devices in conformance with the Specifications:
  1. One set of complete Type P104 Intelligent Pressure Measuring Indicator/Transmitter, furnished complete with accessories specified.
  2. One set of complete Type I107 Digital Indicator, furnished complete with accessories specified.
  3. Five sets of Instrument Tubing Hand Valves.
  4. Five sets of Instrument Tubing Elbow Fittings and Tee Fittings.
- B. Spare instrument shall be configured to match one of the installed instruments.
  1. Where multiple instruments of the same type are installed:
  2. Configuration of spare instrument shall be as directed by Engineer during construction.

3. Request input from Engineer during submittal process as to which configuration is desired for the spare instrument.
- C. Furnish the following tools:
1. One (1) handheld HART communicator configurator, complete with 120 VAC charging station, test lead kit, rechargeable battery, USB cable, carrying case, hand strap, SD card, and software as manufactured by Yokogawa Model YHC5150X FieldMate Handheld Communicator.

## **1.06 ACCEPTABLE MANUFACTURERS**

- A. Each type of Instrument shall be manufactured by a single Instrument manufacturer and additional requirements as follows:
1. All pressure indicating transmitters shall be manufactured by a single Instrument manufacturer.
- B. Refer to the individual instrument subsection in PART 2 - PRODUCTS, below.

## **PART 2 PRODUCTS**

### **2.01 INTELLIGENT PRESSURE MEASURING INDICATORS/TRANSMITTERS**

- A. P100 Series General Requirements:
1. The Pressure Indicator/Transmitter shall have the following features:
    - a. Signal: Two-wire 4-20mA<sub>dc</sub> (loop powered) proportional and linear to Pressure with HART communication protocol.
      - 1) Alarm: Configure the unit fault/alarm at 3.4 mA<sub>dc</sub> output signal.
    - b. Accuracy:
      - 1) Spans greater than or equal to 10% of Upper Range Limit (URL): 0.06 percent of span.
      - 2) All Other: 0.025 + 0.0035 (URL/Span) percent of span.
    - c. Ambient Temperature Range: -40°F to + 175°F.
    - d. Process Temperature Range: -50°F to +250°F.
    - e. DC Loop Supply Voltage Range: 12 to 42 VDC.
    - f. Signal Output Load Range: 200 to 1,450 ohms.
    - g. Transmitter Total Error: 0.1 percent (RMS), at a reference range of 0 to 100 PSI inclusive of all effects.
    - h. Measurement Range: Select the measurement range offered by the instrument manufacturer for the specified model series that offers the greatest available accuracy for the required span of measurement as listed in the Instrument List shown in the PLANS.
    - i. Indicator Requirements:
      - 1) Type: Digital LCD integral to transmitter
      - 2) Calibration: Field configurable, as desired by the user
        - a) Span: As listed in the Instrument List shown in the PLANS.
        - b) Measurement Unit: As listed in the Instrument List shown in the PLANS.
    - j. Power: Loop powered (4-20mA at 24 VDC) with 1/2" NPT conduit connection.
    - k. Sensor Wetted Parts Material: Type 316L Stainless Steel.

- l. Sensor traditional bottom works, process covers and process connectors: Type 316-Stainless Steel with supply vent screw in side of each process cover with traditional bottom works (not coplanar) configuration.
  - m. Sensor Fill Fluid: Silicone oil.
  - n. Process Connection: 1/2 inch NPT.
  - o. Transmitter Housing: Epoxy coated aluminum, explosion proof NEMA-4X.
  - p. Hardware: Type 316 Stainless Steel.
  - q. Local Operation: The Indicator/Transmitter shall be equipped with operators on the face of the unit adjacent to the local indicator for configuration and calibration functions. The face of the unit is the side of the unit that includes the local indicator.
- 2. Process Pipe Pressure Tap Valves: Refer to PLANS for valving on process piping pressure tap, in addition to any instrument valves specified in this section.
  - 3. Mounting: Manufacturer's Type 316 Stainless Steel mounting bracket suitable for mounting transmitter assembly on 2-inch pipe stand, support channel, wall/panel or other surface as shown on PLANS with manifold installed between transmitter and bracket. Provide stainless steel flange to mount vertical pipe stand to floor. Refer to the PLANS for additional requirements.
  - 4. Each Intelligent Pressure Measuring Indicator/Transmitter shall be as manufactured by Foxboro Series IGP20-T (Intelligent Gauge Pressure Transmitters) or Series IAP20-T (Intelligent Absolute Pressure Transmitters) as noted for application with specified accessories, or Engineer approved equal.
- B. P104: Intelligent Pressure Measuring Indicating Transmitter with Block Valve and Tubing
- 1. General Requirements for P100 Series Intelligent Pressure Measuring Indicating Transmitters apply to this type of instrument.
  - 2. Instrument Valves: Provide factory furnished, 2-way Valve Block Manifold; constructed of 316 Stainless Steel wetted and non-wetted parts, to accept 1/2 inch NPT; with gaskets and 316 Stainless Steel bolts; Anderson Greenwood Foxboro Model M4TP-VIS4 with Model AMS Type 316 Stainless Steel mounting bracket or Engineer approved equal. Refer to PLANS for additional valving on process piping pressure tap.
  - 3. Mounting of Manifold and Transmitter: Mount manifold directly with specified manifold mounting bracket. Manifold shall be installed between Transmitter bottom works and bracket. Transmitter shall be supported by manifold.
  - 4. Instrument Tubing: Provide instrument tubing to process line connections at valve block process port. Refer to tubing and fittings requirements in this Specification Section. Refer to PLANS for additional requirements.

## 2.02 DIGITAL INDICATOR

- A. I107 Requirements
- 1. Type: Microprocessor based digital transmitter indicating controller capable of receiving an input analog signal, actuating alarm contacts based upon field configurable setpoints, displaying the input signal, and re-transmitting the input signal via an isolated analog output signal transmitter.
  - 2. Display: 6 digit, 0.6 inch high Light Emitting Diode (LED), red in color
  - 3. Input Signal:
    - a. 4-20mA at 24VDC



- b. Signal proportional to the process variable measured
  - c. Input Impedance: 100 ohms maximum
  - d. Accuracy: Plus or minus 0.03 percent of calibrated span plus or minus one count
- 4. Units: Calibrated in engineering units (applicable to the specific system and measured variable) in order to indicate and control the process variable in the same units (i.e., GPM/MGD for Flow, Inches/Feet for Level, PSI for Pressure, °F/°C for Temperature, etc.).
- 5. Conversion Rate: 5 conversions per second
- 6. Programming Method: Field programmable using buttons on the face of the controller.
- 7. Discrete Outputs: Four field programmable Form C dry output relay contacts each rated for 3 ampere at 120 Vac. Relays shall be capable of being assigned to any combination of high/low set points. Each set point shall have user selectable deadband of 0 to 100 percent of the input signal range. Relays shall be capable of being field programmed for latching, non-latching, and fail-safe operation. The Contractor shall field program the relays for fail-safe operation.
- 8. Output Signal:
  - a. 4-20 mA DC at 24VDC
  - b. Signal proportional to the input signal
  - c. Output signal shall be isolated from the input signal
  - d. Accuracy: Plus or minus 0.1 percent of calibrated span plus or minus 0.004 mA DC.
- 9. Enclosure: 1/8 DIN high impact plastic enclosure with Nema 12 rated front panel at minimum.
- 10. Mounting: 1/8 DIN panel cutout required: Provide two panel mounting bracket assemblies.
- 11. Operating Temperature: -40 to +65 degrees Celsius
- 12. Power: Single phase, 120 Vac input, 60 Hz
- 13. Manufacturer: Precision Digital Model PD6000, or approved equal.

## 2.03 TUBING, HAND VALVES AND FITTINGS

- A. General: Provide tubing, hand valves, and fittings for pressure and differential pressure instruments and other devices as required. Provide as required for a functional installation.
- B. Tubing:
  - 1. Material: ASTM A-213 Type 316 Stainless Steel annealed seamless
  - 2. Size:
    - a. Indoor (Inside Building): 3/8" outer diameter tubing with 0.035" wall thickness.
    - b. Outdoor (Outside of Building): 1/2" outer diameter tubing with 0.049" wall thickness.
    - c. Stand Pipe Ventilation or Other System Ventilation Piping: 1" outer diameter tubing with 0.109" wall thickness.
    - d. Provide other larger size(s) as required.
  - 3. Pressure Rating: 3,000 psi minimum working pressure at 100°F
- C. Metal fittings and Accessories:
  - 1. Type: Swage ferrule design

2. Material: Type 316 Stainless Steel
  3. Size: Same size as tubing
  4. Pressure Rating: Same as tubing
  5. Manufacturer: Crawford "Swagelok", Parker "CPI", Hoke "Gyrolok", or Engineer approved equal.
- D. Valves:
1. Type: Full port ball valves
  2. Material: Type 316 Stainless Steel trim and body
  3. Seats and packing: Teflon
  4. Size: Same size as tubing
  5. Pressure Rating: Same as tubing
  6. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.
- E. Provide stainless steel reducer/transition fittings at instrument/process piping and tubing connections.
- F. Bulkhead Fittings:
1. General Requirements:
    - a. Material: Type 316 Stainless Steel trim and body
    - b. Size: Same size as tubing
    - c. Pressure Rating: Same as tubing
    - d. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.
  2. Tubing to Tubing Unions:
    - a. Fitting: Bulkhead Union, Hoke BU or Engineer approved equal.
    - b. Connection Type, Both Ends: Swage ferrule design
  3. Tubing to Test Port:
    - a. Fitting: Bulkhead Union, Hoke BU or Engineer approved equal.
    - b. Connection Type, Both Ends: Swage ferrule design
  4. Tubing to Vent Screen Fitting:
    - a. Fitting: Bulkhead Union, Hoke BU with or Engineer approved equal.
    - b. Tubing Connection Type: Swage ferrule design with standard nut.
    - c. Screen Connection Type: Swage ferrule design with knurled nut, Hoke KN or Engineer approved equal.
- G. Vent Screen Fittings:
1. Material: Type 316 Stainless Steel trim and body
  2. Size: Same size as tubing or pipe vent screen fitting is connected to.
    - a. Available vent screen fitting sizes shall include 1/4", 3/8", 1/2", 3/4", and 1" in diameter.
    - b. Vent screen fitting shall be of equal diameter or the next listed size greater than the tubing/piping the vent screen fitting is connected to.
    - c. Provide reducer fitting between vent screen fitting and tubing/piping as required.
    - d. Where tubing/piping is larger than 1" diameter, provide 1" size vent screen fitting and necessary reducer fitting to connect to tubing/piping.
  3. Pressure Rating: Same as tubing
  4. Fitting: Screen, Hoke SCRIN or Engineer approved equal.
  5. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.

- H. Tubing Support System:
  - 1. UNISTRUT Cush-A-Clamp Assembly Pipe/Tube Clamp (1-5/8" Series), or Engineer approved equal, with controlled squeeze shoulder bolt for all clamping of instrument tubing.
  - 2. Refer to Specification Section 16150 "Raceways, Fittings, and Supports" for instrument tubing support channel system additional requirements.
- I. Manifolds:
  - 1. Instrument Valves: Provide factory furnished, 2-way Valve Block Manifold; constructed of 316 Stainless Steel wetted and non-wetted parts, to accept 1/2 inch NPT; with gaskets and 316 Stainless Steel bolts; Tyco Flow Control Anderson Greenwood Model M4TP-VIS4 or approved equal.

## **2.04 HOODS (SUN SHIELDS)**

- A. Furnish and install an aluminum HOOD (Sun Shield) on top of Indicator Instruments, Transmitter Instruments, Indicating/Transmitter Instruments, Analyzer Instruments, Controller Instruments and Instrument Elements that are mounted OUTDOORS or below flanges mounted OUTDOORS:
  - 1. Aluminum HOOD installation shall apply for all field instrumentation installed OUTDOORS, inclusive of field instrumentation specified in this Section and specified in Sections 11376E, 17302 and 17305 as well as instruments specified or provided by the Blower manufacturer.
  - 2. Secure HOOD to the instrument, instrument flange mounting assembly and/or instrument support rack and provide all additional mounting hardware necessary for the installation of the Hood Assembly.
  - 3. HOOD shall be a fabricated component and shall be fabricated from minimum 0.1" thickness, aluminum alloy 3003-H14 sheet (ASTM B209). All seams or joints of HOOD shall be closed by continuous weld.
  - 4. Secure HOOD to the associated instrument supports utilizing 316 Stainless Steel hardware. The top of the Hood shall clear the top of the associated instrument by 6 inches. The side visors of the Hood shall clear both sides and rear of the associated instruments by 4 inches.
  - 5. Proposed aluminum HOOD shall have a double-wall aluminum construction top plate and a minimum one inch thick phenolic foam insulation board installed between the two top walls/plates. Phenolic foam material shall comply with the following:
    - a. Block shape cut to fit entire double-wall void within the double-wall top plate.
    - b. Shall be rigid, expanded, closed-cell structure in compliance with ASTM C 1126, Type II, Grade 1.
    - c. As manufactured by:
      - 1) Kingspan Tarec Industrial Insulation NV; Koolphen K,
      - 2) Resolco International BV; Insul-phen, or
      - 3) Engineer approved equal.
- B. Refer to PLANS for additional requirements for construction and mounting of HOOD.

## **2.05 WIRE MESH GRIP**

- A. General: Furnish and install heavy duty wire mesh grip to support suspended floats, transducers, etc. as required. Refer to the details shown on the PLANS. Coordinate size of mesh grip required with cable to be supported. Mesh grip shall have the following features:
1. Material: Type 316 Stainless Steel
  2. Breaking Strength: 1000 lbs, minimum
  3. Manufacturer: Hubbell- Kellums "Heavy Duty, Single Eye, Closed Mesh, Multi-Weave" model series 024170xx, where "xx" is adjusted according to cable diameter. Coordinate cable diameter with the PLANS.

## **2.06 STAND PIPES**

- A. Where PLANS show a stand-pipe (also referred to as a stilling-well), provide the following pipe, flange and blind flange components:
1. Indoor Applications not Exposed to Sunlight:
    - a. The stand-pipe shall be an ASTM D 1784 Schedule 80 PVC Pipe of diameter and length as shown on PLANS. Manufactured by Havel Pipe or approved equal.
    - b. Provide an ASTM D 1784 Schedule 80 single piece socket flange fitting with slip-on solvent weld connection to pipe. Carefully apply solvent so as not to drip past fitting. Flange shall be Class 150 ANSI B16.5. Flange diameter to match stand-pipe diameter shown on PLANS. Manufactured by NIBCO or approved equal.
    - c. Provide a Type 316 Stainless Steel Schedule 40 Blind Flange with Type 316 Stainless Steel bolts, washers, and nuts hardware assembly to fasten blind flange to flange fitting. Pipe flange and blind flange bolt patterns shall match. Blind flange cap diameter to match stand-pipe diameter shown on PLANS. Manufactured by Warren Alloy or approved equal.
    - d. Fabricate a handle made of the same material as the blind flange and welded to the top face of the blind flange. Refer to the PLANS for additional requirements, including blind flange handle geometry.
  2. Outdoor and/or Sunlight Applications:
    - a. Where stand-pipe is mounted outdoor and/or under sun light, the stand-pipe shall be an ASTM B 221 Schedule 40 Type 6061-T6 Extruded Aluminum Pipe of diameter and length as shown on PLANS.
    - b. Provide a Type 6061-T6 Aluminum Flange with full aluminum welded connection to pipe. Flange shall be Class 150 ANSI B16.5. Flange diameter to match stand-pipe diameter shown on PLANS.
    - c. Provide a 6061-T6 Stainless Steel Schedule 40 Blind Flange with Type 316 Stainless Steel bolts, washers, and nuts hardware assembly to fasten blind flange to flange fitting. Pipe flange and blind flange bolt patterns shall match. Blind flange cap diameter to match stand-pipe diameter shown on PLANS.
    - d. Fabricate a handle made of the same material as the blind flange and welded to the top face of the blind flange. Refer to the PLANS for additional requirements, including blind flange handle geometry.
  3. Stand-pipe mounting hardware and support brackets shall be manufactured from Type 316 Stainless Steel. Refer to the details on the PLANS.

## **PART 3 EXECUTION**

### **3.01 STORAGE AND HANDLING**

- A. The field instrumentation and control devices shall be handled carefully to prevent damage. Units shall be stored in a weatherproof structure prior to installation.

### **3.02 INSTALLATION**

- A. General: The following apply to all products in this Section:
  - 1. Unless otherwise specified, all instrument mounting channels, pipes, pipe caps, etc. shall be Type 316 stainless steel; also, all hardware connecting and securing the mounting hardware and instruments such as nuts, bolts, instrument tubing Cush-A-Clamp Assembly Pipe/Tube Clamp etc. shall be Type 316 Stainless Steel.
  - 2. All field mounted sensor/control/instrument devices shall be permanently identified. The device designations shall agree with those shown on the PLANS. Each device shall be provided with permanent type identifying nameplate. Nameplates, unless otherwise specified, shall be shaped as a circle and shall be constructed of 3-ply "White-Black-White" laminated phenolic material having engraved letters approximately 1/4 inch high extending through the white face into the black layer. Securely hang nameplates from each sensor/control/instrument device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).
  - 3. Nameplates:
    - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
    - b. Color: White-Black-White
    - c. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer.
    - d. Accessories: Provide holes for mechanical fastening.
    - e. Attachment Means: Securely hang nameplates from each sensor/control/instrument device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).
  - 4. Submit listing of all field instruments tag numbers for verification by OWNER.
  - 5. Install, set, adjust and test all devices per the requirements of Section 17100 of the Specifications. Also, setpoint values shall be reviewed by and coordinated with the OWNER/ENGINEER.
  - 6. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure to each unit prior to installation.
  - 7. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure to each unit prior to installation.
  - 8. The instruments specified under this Section of the Specifications shall be installed and calibrated to match its respective system and per the requirements of the Contract Documents and as recommended by the manufacturers.
  - 9. Verify ranges with Owner and Engineer prior to ordering instruments.

10. Refer to Specification Section 16150 "Raceways, Fittings, and Supports" for instrument support channel system requirements.
  11. Make all final connections and terminations per the instrument manufacturers' recommendations.
  12. Unit and Range of each instrument from the Instrument shall as required and shall be clearly noted on the instrument Submittals. Instrument ranges shall be confirmed via the submittal process with the Owner prior to ordering any of the Field Instrumentation and Sensing Devices specified under this Section of the Specifications. Select instruments within approved manufacturer series that provide the greatest level of accuracy within the span of required measurement.
  13. Submit comprehensive calibration sheets to the OWNER indicating "as found" and "final settings". Submit a typical (blank) field calibration sheets/forms to the OWNER for review and comment prior to utilizing the same for recording calibration parameters. Include final field calibration settings in the Operation and Maintenance Manuals.
  14. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
  15. Provide manufacturer's services to perform start-up and calibration/verification.
  16. Verify factory calibration of all instruments in accordance with the manufacturer's instructions. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.
  17. Furnish and install an aluminum HOOD (Sun Shield) on top of Indicator Instruments, Transmitter Instruments, Indicating/Transmitter Instruments, Analyzer Instruments, Controller Instruments and Instrument Elements that are mounted OUTDOORS or below flanges mounted OUTDOORS. Refer to the PRODUCT PART 2 Section of this specification and the PLANS for additional requirements on the construction and installation of each HOOD.
- B. Pressure Instruments:
1. Testing:
    - a. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure at 0%, 50% and 100% minimum increments of span to each unit prior to installation.
  2. Pressure Indicating/Transmitters Serving Liquid Process Lines:
    - a. Install instruments with instrument tubing such that the elevation of pressure tap(s) on transmitter bottomworks is 3" minimum below the elevation of the pressure tap(s) on the process piping//flow-tube element (i.e. venturi, orifice plate, etc.) served and all instrument tubing is above the transmitter bottomworks pressure tap(s) and sloping up towards the pressure tap(s) of the process piping/flow-tube element served.
      - 1) Exception: Pressure instruments with diaphragm seals can be installed above the pressure taps of the process piping//flow-tube element served. However, all piping between the diaphragm seal and the process pipe shall be horizontal.
- C. Instrument Tubing: Gas and Liquid Tubing
1. Install tubing and supports so as not to interfere with work space/maintenance access of existing and proposed equipment.

2. Make all instrument tubing system connections air/water tight. Provide proper thread/joint sealant such as Teflon brand strips or other approved sealant where connecting to equipment/accessories/fittings.
3. Requirements herein relate to process pressure port taps/connections shall apply to flow-tube element (i.e. venturi, orifice plate, etc.)connections as well.
4. Tubing Support Systems:
  - a. Clamp all instrument tubing onto channel supports. As a minimum, support and clamp all instrument tubing as follows:
    - 1) Gas and Liquid Tubing: at 2'-6" intervals on horizontal and vertical runs, and no more than 3" from each elbow and tee fitting.
    - 2) Capillary Tubing: at 12" intervals on horizontal and vertical runs.
  - b. Provide suitable floor mounted or ceiling hung channel support systems necessary for mounting/fastening of instrument tubing.
  - c. Overhead or wall support systems for tubing shall be independent of other conduit/pipe support systems and shall solely support instrument tubing systems.
5. Instrument Tubing Conveying Liquid:
  - a. Pressure port tubing connections to process piping and flow-tube elements shall be installed on the side (spring line) of horizontal process pipes and flow-tube elements.
  - b. Horizontal runs of tubing installed lower than the process pipe tap connection shall be sloped 10% up towards process pipe.
  - c. Tubing installed higher than the process pipe tap connection shall have a vent valve installed at its highest point. Slope tubing 10% up towards valve. Provide additional vent valves at highest points/segments of instrument where air/gas can accumulate.
    - 1) Note:
      - a) Instrument tubing serving pressure indicating/transmitter having no diaphragm seal shall not be installed above the process pipe tap connection. Refer to pressure indicating/transmitter installation requirements.
  - d. Do not install instrument tubing conveying liquids directly over electrical panels/equipment. Provide a 3'-0" distance, as seen in plan view, between liquid filled instrument tubing and electrical power distribution equipment.
6. Instrument Tubing Conveying Air/Gas:
  - a. Pressure port tubing connections to process piping and flow-tube elements shall be installed on the top crest position of horizontal process pipes and flow-tube elements.
  - b. Horizontal runs of tubing installed higher than the process pipe tap connection shall be sloped 10% down towards process pipe connection.
  - c. Tubing installed lower than the process pipe tap connection, shall have a condensate drip leg and drain valve. Drip leg pipe segment shall be 6" long. Install instrument tubing at a 10% slope down towards drip leg.
7. Instrument Tubing Cutting and Fittings:
  - a. Cut tubing with sharp cutting tool. Do not flatten tubing or in any way distort the manufacturer original tube diameter dimensions.
  - b. File edges of tubing after cutting and remove any filings/shavings prior to making connections.
  - c. Provide elbow fittings, tee fittings, reducer fittings, and valves at tube connections. Bending tubing in lieu of elbow fittings is not acceptable.

- d. Clean inside of tubes prior to operation. Clean by blowing out to ensure there is no debris in tubes.
- D. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents. Instruments may be shown on the PLANS, in the Specifications or both.

### **3.03 OPERATION AND MAINTENANCE TRAINING**

- A. Start-up Training: Provide required instruction to the OWNER's personnel during start-up period.
- B. Special Training School: Provide services of a factory-trained instructor or instructors for each of the specified and installed Field Instrumentation and Sensing Devices for a total period of not less than three (3) working days for the purpose of instructing the OWNER's personnel in the correct operating and maintenance procedures for all the Field Instrumentation and Sensing Devices specified under this Section of the Specifications and installed in this project. One (1) of the three (3) days of services shall be dedicated for the purpose of instructing the OWNER's personnel in the correct operating and maintenance procedures for the Type L205 Sludge Blanket Level Element and Indicating Transmitter. The Field Instrumentation and Sensing Devices training is in addition to the training requirements defined in other Sections of Division 17 of the Specifications. The date of this school shall be scheduled with the OWNER, but will be after the entire instrument and control system is in operation and respective Operation and Maintenance Manuals have been submitted and revised per ENGINEER comments. Also, refer to the additional training requirements defined in other Sections of Division 17 of the Specifications.
  - 1. Provide one (1) month prior notice to schedule class events with OWNER.
  - 2. Submit detailed listing of class curriculum including, as a minimum, with the following at least four (4) months prior to class:
    - a. Specific topics for each instrument, including but not limited to, general trouble-shooting, calibration, wiring, and general set-up/configuration.
    - b. Anticipated duration of class for each instrument type.
    - c. Names of instructor(s) for each specific instrument.
    - d. Refer to instrument by Instrument Type Code as listed in this specification section where applicable.

### **3.04 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION



## **SECTION 17600**

### **DISTRIBUTED CONTROL SYSTEM**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Furnish all labor, materials, equipment, and incidentals required, and shall install complete, ready for operation, and test the distributed control system, hereinafter termed the System as shown on the PLANS and as specified.
- B. The Instrument and Control System Contractor (ICS) shall provide equipment, materials, software, calibrations, training, startup assistance and system check-out, and other services that are required to successfully interface and interconnect the System and associated equipment that are specified or designated in PLANS or provisions of these specifications for the purpose of providing a fully integrated and functional control system as specified.
- C. The ICS shall be responsible for furnishing and installing the Communication System for the Distributed Control System "DCS" shown on the PLANS (installation and testing of the Ethernet cable and validation of communication system), and as specified hereinafter.
- D. The ICS shall be responsible for all modifications to the Owner's existing distributed control system as also shown on the PLANS.
- E. Refer to the PLC Input/Output Schedule and wiring schematics on the PLANS and other subsections of this Specification Section for requirements related to the PLC Input/Output.

##### **1.02 DISTRIBUTED CONTROL SYSTEM DESCRIPTION**

- A. General:
  - 1. The Distributed Control System (DCS) as shown on the PLANS and specified herein, includes, but is not limited to, the following:
    - a. Programmable Logic Controllers Subsystem (PLCs),
    - b. Communication System Application and System Software,.
    - c. PLC networking/data communications over existing and proposed Ethernet TCP/IP network as well as Modbus Plus network
    - d. Interface with Power Monitoring Units, Protective Relays, and other devices as shown on the PLANS.
    - e. Interface with process/mechanical equipment having packaged control systems as shown on the PLANS.

##### **1.03 RELATED SPECIFICATIONS**

- A. Refer to Section 17100.

- B. This Section covers work related to the Distributed Control System DCS and its Subsystems. Note that this Section does not stand-alone. Many key technical definitions, functional requirements, training, submittals, etc. requirements for the DCS are given in Section 17100 "Process Instrumentation and Control Systems (PICS)".

#### **1.04 DISTRIBUTED CONTROL SYSTEM (DCS) SUBMITTALS**

- A. General: Submit the following in accordance with the Section 01300 of the Specifications.
- B. Hardware:
  - 1. Shop drawings, product data, bill of materials
  - 2. Control system architecture block diagram,
  - 3. Wiring diagrams
  - 4. Spare parts listing.
- C. Ethernet System Copper Cable Testing Submittal: Where Ethernet copper cables are required to be installed, provide a complete set of cable test results for the testing required under subsection Ethernet System Copper Cable – Source Quality Control", this Section of the Specifications. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications. Provide the OWNER with a typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, test values, results. Test reports shall be signed by the ICS representative
- D. Operations and Maintenance O&M Manuals:
  - 1. Hardware: As minimum, provide the following:
    - a. Final approved versions of all shop drawing submittals.
    - b. Component Manufacturers' O&M Manuals including manuals to cover installation, operation, maintenance, troubleshooting, and calibration.
    - c. List of spare parts and expendables provided and list of spare parts recommended.
- E. Additional submittals as required by Specifications Section 17100, Section 01300 and Section 01730 of the Contract Specifications.
- F. Refer to the requirements of Specifications Section 17100.

#### **1.05 SPARE PARTS**

- A. Provide the following spare parts at minimum for each applicable component that has been furnished on this project (if the component is not furnished for the project, then the spare part of that same component is not required):
  - 1. Provide the following SPARE equipment, complete with all accessories:
    - a. PLC processor units (CPU Modules): Two (2) of each type used
    - b. PLC power supply units: Ten Percent (minimum of 2) of the number required for each type of PLC used
    - c. PLC RIO Head module: Ten Percent (minimum of 2) of the number required for each type of PLC used
    - d. PLC RIO Drop Module: Ten Percent (minimum of 2) of the number required for each type of PLC used

- e. PLC I/O Module (AI, AO, DI, DO): Ten Percent (minimum of 2) of the number of each type used.
- f. PLC rack: One (1) of each type used.
- g. PLC rack extender module, terminator, and cabling: Ten Percent (minimum of 2) of the number required for each type of PLC used.
- h. Local Area Network (LAN) system component (converter, modem, transceiver, etc.): Ten percent (minimum of 2) of each type provided
- i. Ethernet NOE module: Ten Percent (minimum of 2) of the number required for each type of PLC used.
- j. One (1) ethernet switch complete with all modules for each type used
- k. One (1) spare Type 1 OIU complete with all accessories.
- l. All spare parts shall be of the same manufacturer, model, and software revision as the installed component, and shall be provide complete with all accessories.

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

- A. Refer to Section 17100.
- B. General Requirements:
  - 1. Power source parameters:
    - a. 120 volts A.C., plus or minus 10 percent, 60 Hertz
    - b. Regulators and power supplies required for compliance with the above shall be provided.
  - 2. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.
  - 3. All components and interconnecting wiring shall be provided as required to satisfy the functional and operational requirements of this Specification.
  - 4. All equipment to be installed in a control panel or on a rack, including switches, etc., shall be tagged according to the guidelines outlined in Section 17200 "Instrumentation and Control Cabinets and Associated Equipment", of these Specifications.
  - 5. Unless otherwise specified, tag each outlet face plate with white Label with black lettering of minimum height ¼" where label is TTP Continuous polyester thermal transfer label as manufactured by Tyco, or approved equal, with ribbon and printer by label manufacturer.
  - 6. Communication Cables: Provide all cables for interconnection between all components of the DCS inside the and/or in duct/conduit banks, as applicable. These cables shall include cables to the various PLCs I/O racks, power supplies, central processing units, patch panels, ethernet switches, computers, etc. All cables shall be tagged per Section 17200 "Instrumentation and Control Cabinets and Associated Equipment".
  - 7. All equipment cabling, including copper Ethernet cable, all patch cords, etc., shall be tagged according to the guidelines and tagging labeling system outlined in Section 17200 "Instrumentation and Control Cabinets and Associated Equipment", of these Specifications. For tagging of cables with manufacturer pre-connected cable ends, e.g. patch cords, power cords, etc., furnish and install SP self-laminating polyester labels (minimum 2" long along length of cable) with thermal transfer printable, low profile translucent polyester

film with a permanent acrylic adhesive as manufactured by Tyco, or approved equal, with respective printer and ribbon type by label manufacturer. Tag all S.O. type power cords with the tag of the equipment served.

## **2.02 PROGRAMMABLE LOGIC CONTROLLERS (PLCS)**

### **A. General:**

1. Provide all hardware and software features required to make the PLCs totally operational.
2. The PLCs shall include, but not be limited to, the equipment components called for on the PLANS and in these specifications. Capacities and/or quantities shown are minimum. Provide additional capacity or units as necessary to meet the functional requirements.
3. Availability:
  - a. Subsystem Availability Calculation: The Subsystem availability (A) for the PLC's is defined as average of the individual PLC availabilities ( $A_i$ ) times the nonspecific availability (NA). That is,  $A = NA \cdot (A_1 \cdot A_2 \cdot A_3 \dots \cdot A_n) / n$ , where n is the number of PLC's.
  - b. Availability Requirements: The PLC's availability shall be at least 99 percent.
  - c. Component and Backup Definitions: For purposes of the availability calculations, each PLC, each PLC power supply, its process I/O, and data highway interface is considered to be an individual component. There are no backup components.
4. Communications:
  - a. Failure of any PLC or DCS component connected to the communications system network shall not affect the ability of the remaining components on the network to communicate with each other.
  - b. Data Highway DH Link Requirements:
    - 1) Fast Ethernet (100BaseFX), as minimum
    - 2) Minimum operating distance: 10,000 feet
    - 3) Rate: 10/100 Mbps.
  - c. The remote I/O shall be single channel, Ethernet, in a ring network topology. All remote I/O cabling and installation shall be in accordance to the Modicon M580 System Planning Guide.
  - d. All copper Ethernet cables shall have a category 6A RJ-45 connector and category 6A cable. The connector end shall be the Boot type connector and preinstalled by the Ethernet patch cable manufacturer.
  - e. Modbus and Modbus Plus shall be in accordance to the Square D standard for cable pin out and cable type, as well as the end devices to be interconnected. The cables shall be shielded. Refer to the Square D Modicon Hardware Reference Guide for Modbus serial cable pin out and guidelines. Furnish and install ruggedized taps and terminators were available from the manufacturer.

### **B. Type 1 Programmable Logic Controllers (PLCs):**

1. Each programmable logic controller shall consist of central processor, process controller, power supply, memory, input/output, interconnecting cables, and optional items as specified.

2. Power Supply:
  - a. Manufacturer: MODICON M580 Automation Series model number BMX CPS 3500, No Equal.
  - b. Accessories: Provide screw clamp type removable terminal blocks, Modicon M580 model number BMX XTS CPS10 No Equal.
3. Central Processor:
  - a. Memory: 65535 Kbytes, at minimum
  - b. Ports: 1 mini B Universal Serial Bus (USB) port, 1 Ethernet service port, and 2 Ethernet Modbus TCP/IP port
  - c. Accessories: Provide a 4 GB SD Memory Card, as manufactured by the CPU manufacturer.
  - d. Manufacturer: Schneider Electric MODICON M580 BME P58 4040, No Equal.
4. Discrete Input Module DI:
  - a. Manufacturer: MODICON M580 Automation Series Model number BMX DAI 1604 No Equal.
5. Discrete Output DO:
  - a. Manufacturer: MODICON M580 Automation Series model number BMX DRA 0815 No Equal.
6. Analog Input Module AI:
  - a. Manufacturer: MODICON M580 Automation Series model number BMX AMI 0810 No Equal. With each module, furnish and install cage clamp terminal block Modicon Model BMXFTB2800, No Equal.
7. Analog Output Modules AOs:
  - a. Manufacturer: MODICON M580 Automation Series model number BMX AMO 0410 No Equal
8. Network Option Ethernet (NOE):
  - a. Manufacturer: Modicon M580 Automation Series model number BME NOC 0311 Module, No Equal.
9. PLC Racks
  - a. X bus and Ethernet Bus interface. Manufacturer: MODICON M580 Automation Series model number BME XBP 1200 No Equal
10. PLC Rack Extender Module:
  - a. Accessories:
    - 1) Provide X bus extender cord, length as required per PLANS, manufactured by Extender Module manufacturer, model number BMX XBC series No Equal.
    - 2) Provide line terminator for extender module located at each end of the daisy chain, manufactured by the Extender Module manufacturer, model number TSXTLYEX, No Equal.
  - b. Manufacturer: MODICON M580 Automation Series model number BMX XBE 1000 No Equal
11. Remote I/O Drop Module:
  - a. Manufacturer: MODICON M580 Automation Series model number BME CRA 31210 No Equal.
12. Accessories:
  - a. Unless specified otherwise, provide 20-way screw clamp type removable terminal block with each module, Modicon Model BMXFTB2010, no equal.

- C. Type 2 Programmable Logic Controllers (PLCs):
1. Each programmable logic controller shall consist of central processor, process controller, power supply, memory, input/output, interconnecting cables, and optional items as specified
  2. Power Supply:
    - a. Manufacturer: MODICON M340 Automation Series model number BMX CPS 3500, No Equal
    - b. Accessories: Provide screw clamp type removable terminal blocks, Modicon M340 model number BMX XTS CPS10 No Equal.
  3. Central Processor:
    - a. Memory: 4096 Kbytes, at minimum
    - b. Ports: 1 mini B Universal Serial Bus (USB) port, 1 Modbus communication port, and 1 Ethernet Modbus TCP/IP port
    - c. Accessories: Provide a 16 MB FLASH Memory Card, as manufactured by the CPU manufacturer.
    - d. Manufacturer: Schneider Electric MODICON M340 BMX P34 2020, No Equal
  4. Discrete Input Module DI:
    - a. Manufacturer: MODICON M340 Automation Series Model number BMX DAI 1604 No Equal
  5. Discrete Output Module DO:
    - a. Manufacturer: MODICON M340 Automation Series model number BMX DRA 0815 No Equal
  6. Analog Input Module AI:
    - a. Manufacturer: MODICON M340 Automation Series model number BMX AMI 0810 No Equal
  7. Analog Output Module AO
    - a. Manufacturer: MODICON M340 Automation Series model number BMX AMO 0410 No Equal
  8. Network Option Ethernet (NOE)
    - a. Manufacturer: Modicon M340 Automation Series model number BMX NOE 0100 Module, No Equal
  9. PLC Racks:
    - a. Manufacturer: MODICON M340 Automation Series model number BMX XBP 1200 No Equal
  10. PLC Rack Extender Module:
    - a. Accessories: Provide extender cord, length as required per PLANS, manufactured by Extender Module manufacturer, model number BMX XBC series No Equal.
    - b. Manufacturer: MODICON M340 Automation Series model number BMX XBE 1000 No Equal
  11. Accessories:
    - a. Provide 20-way screw clamp type removable terminal block with each module, Modicon Model BMXFTB2010, no equal.

## **2.03 OPERATOR INTERFACE UNIT**

- A. General: Where required, the OIU shall effectively be a Graphical front end to the local PLC network and have complete read/write access to all registers of the local PLC network to which the OIU is connected.

1. Communication:
  - a. The OIU shall utilize Ethernet communication protocols to communicate to other peripheral devices, including PLC's, as shown in the contract drawings.
  - b. The ICS shall provide the necessary cabling for communicating with the OIU for programming and configuration purposes with a personal computer. The program cabling shall be USB and minimum of 12 feet in length.
  - c. The ICS shall install the necessary cabling, connectors, and termination for communication between the OIU Ethernet interface and the Ethernet network.
2. Software:
  - a. Operating System: Magelis Operating system, with latest service Pack, preinstalled by the OIU manufacturer.
  - b. Software: Vijeo Designer run time software, preinstalled by the OIU manufacturer.
  - c. All additional necessary software, software drivers, etc. complete with all licenses, as necessary for the proper operation of the OIU.
3. Mounting:
  - a. Mount in control panel door as shown on the Drawings. All communication ports shall be accessible with OIU installed in the control panel.
  - b. Provide mounting hardware as required and install OIU according to manufacturer's instructions and requirements. Provide trim accessories to seal the gap between the OIU and control panel door.
4. Accessories:
  - a. 1 Gigabyte secure digital (SD) card, manufactured by the OIU manufacturer.
  - b. All necessary cables, connectors, and terminators. Minimum cable length shall be 12 feet

B. Display Module:

1. Type: Flat Color Active Matrix (TFT) LCD display type, with touch screen capability
2. Size: 15" diagonal
3. Minimum Resolution: 1024 x 768 pixels,
4. Colors: 16,000,000 colors
5. Power Input: 24 volts DC.
6. Communication Ports:
  - a. One (1) USB 2.0 Type A port,
  - b. One (1) USB 2.0 Mini-B port
7. Physical Environment:
  - a. Ambient Air Temperature: +32° to +140° Fahrenheit
  - b. Ambient Air Humidity: 10% to 90% Relative Humidity Non-condensing
  - c. Free of corrosive gases
8. Cooling Method: Natural air circulation
9. Enclosure: NEMA 4X rated
10. Manufacturer: Schneider Electric Magelis GTU HMIDT732, No Equal.

C. Box Module:

1. Power Input: 24 volts DC.

2. Memory:
  - a. System Card: SD Card 1 GB
  - b. Internal Memory: 256 MB RAM
  - c. Backup Memory: 512 kB NVRAM
3. Communication Ports:
  - a. Two (2) RJ-45 Ethernet ports,
  - b. Two (2) USB 2.0 Type A ports,
  - c. One (1) USB 2.0 Mini-B port,
  - d. One (1) RJ-45 RS-485 serial port,
  - e. One (1) 9 pin RS-232/422/485 serial port,
  - f. Two (2) SD card slots [one (1) system and one (1) storage]
4. Communication Protocol: Ethernet, Modbus TCP/IP
5. Output Interface:
  - a. One (1) 300 mW speaker output,
  - b. One (1) 24 VDC auxiliary alarm output
6. Physical Environment:
  - a. Ambient Air Temperature: +32° to +140° Fahrenheit
  - b. Ambient Air Humidity: 10% to 90% Relative Humidity Non-condensing
  - c. Free of corrosive gases
7. Cooling Method: Natural air circulation
8. Manufacturer: Schneider Electric Magelis GTU HMIG3U, No Equal.

## 2.04 ETHERNET SWITCHES

- A. General:
  1. Provide and install Ethernet switches for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components herein shall be provided as minimum for bidding purposes. It is anticipated that Ethernet Switch technology will advance over time and the latest model of Ethernet switch having the features specified hereinafter as a minimum shall be furnished and installed.
  2. All switches shall be provided with the latest firmware from the manufacturer, where applicable. Switches to be stacked must be supplied with the same feature set, IP LAN, IOS, etc. Contractor shall furnish Ethernet switch stack cabling for switches capable of being stacked. Owner shall install Ethernet switch stack cabling.
  3. All switches shall be supplied with the manufacturer's support contract for the duration of two years starting from final completion of the project. At minimum switches manufactured by Cisco shall have the Cisco SMART NET for a minimum of two (2) years starting from final completion of the project and registered in the name of the Owner.
  4. SFP Module: Each SFP module shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector. All SFP modules shall be as manufactured by Cisco.
  5. Should the specified switch be designated as "End of Life" and/or discontinued by its manufacturer, contractor shall furnish and install an alternate switch, whose specifications meet or exceed the specified switch, by the same manufacturer and that is not designated as "End of Life" and/or discontinued by the switch manufacturer.
- B. Type 1 Ethernet Switches:
  1. Power Input: 120 volts A.C., 60 Hz



2. Port Quantity and Type: 24 10/100/1000BaseTx ports, and modular uplink module to support 4 sockets for SFP 1G/10G modules. Note: The previously specified quantity of ports shall be provided even if the PLANS show lesser quantity of ports.
  3. Module: Furnish and install minimum four (4) 1000BaseLX/LH SFP modules in each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector.
  4. Manufacturer: Cisco Catalyst C9200-24T-A, or approved equal.
- C. Type 2 Ethernet Switches:
1. Provide Type 1 Ethernet Switch, this Section of the Specifications, with the exception that the copper Port Quantity shall be 48 10/100/1000BaseTx ports and that only two SFP modules are required.
  2. Furnish and install second, redundant power supply for this switch.
- D. Type 3 Ethernet Switches:
1. Provide Type 1 Ethernet Switch, this Section of the Specifications, with the exception that the SFP modules are not required.
- E. Type 4 Ethernet Switches:
1. Power Input: 120 volts A.C., 60 Hz.
  2. Port Quantity and Type: minimum 24 10/100/1000Base TX ports, 4 of which are dual purpose ports which the user may elect to use as a 10/100/1000Base TX port or as a socket for an SFP module.
  3. Module: Provide minimum one (1) 1000BaseLX/LH SFP modules with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector.
  4. Mounting: 19-inch rack mounting with necessary kit. Refer to the PLANS.
  5. Accessories:
    - a. LAN Base image
    - b. For each Ethernet switch, furnish and install 120VAC Ethernet Switch power supply, model PWR-RGD-AC-DC-250 by Cisco.
  6. Manufacturer: Cisco Industrial Ethernet Switch IE-4010-4S24P.
- F. Type 5 Ethernet Switches:
1. Power Input: 24 volts D.C.
  2. Port Quantity and Type: Eight (8) 10/100 BaseTx Ethernet ports
  3. Switch shall be the unmanaged type and without power over Ethernet
  4. Operating Temperature Range: -40 degrees Celsius to 85 degrees Celsius
  5. Accessories: 2 year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the Owner.
  6. Manufacturer: N-Tron 508TX, or approved equal
- G. Type 6 Ethernet Switches:
1. Power Input: 24 volts D.C.
  2. Port Quantity and Type: Five (5) 10/100 BaseTx Ethernet ports
  3. Switch shall be the unmanaged type and without power over Ethernet
  4. Operating Temperature Range: -40 degrees Celsius to 85 degrees Celsius
  5. Accessories: 2 year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the Owner.
  6. Manufacturer: N-Tron 405TX, or approved equal.

- H. Type 7 Ethernet Switches:
  - 1. Power Input: 120 volts A.C., 60 Hz
  - 2. Port Quantity and Type: Eight (8) 10/100/1000 BaseTx Ethernet ports and 2 combo ports. Each combo port shall consist of one (1) SFP based Gigabit Ethernet port.
  - 3. Module: Provide minimum two (2) 1000BaseLX/LH SFP modules with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector.
  - 4. Enclosure: Sealed, rated NEMA 4X
  - 5. Mounting: DIN rail mount or 19-inch rack mounting with necessary kit, as applicable. Refer to the PLANS.
  - 6. Software: LAN Base manufacturing license
  - 7. Accessories:
    - a. Provide a one year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the OWNER
    - b. For each Ethernet switch where shown to be installed on 19" rack in PLANS, furnish and install 19-inch DIN-rail adapter for rack mounting, model STK-RACK-DINRAIL= by Cisco, or approved equal.
    - c. For each Ethernet switch, furnish and install 120VAC Ethernet Switch power supply, model PWR-IE170W-PC-AC= by Cisco, or approved equal.
  - 8. Manufacturer: Cisco Industrial Ethernet IE-4000-16GT4G-E, or approved equal.
- I. Accessories:
  - 1. Furnish and install mounting brackets and hardware as required to install each Ethernet Switch according to manufacturer's instructions and requirements
  - 2. Furnish and install all necessary cables, connectors, and terminators as required for a complete and functional installation

## **2.05 ETHERNET COPPER CABLES AND CONNECTORS AND HARDWARE GENERAL SPECIFICATIONS REQUIREMENTS**

- A. General:
  - 1. Provide and install copper cables, connectors, patch panels, and cords for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components herein shall be provided as minimum for bidding purposes.
  - 2. Ethernet Copper Connectors: All copper Ethernet cables shall have a Category 6A boot type RJ-45 connector.
  - 3. The installed Ethernet copper media system (including cable, data outlets, connectors, patch cords, patch panels, etc.) shall at minimum meet the TIA/EIA-568-C.2-10 Category 6A standards.
- B. Ethernet Copper Patch Cords:
  - 1. The Ethernet Copper Patch Cord shall be used to connect a communication device with a patch panel or Ethernet Copper Data Outlet. The Ethernet Copper Patch Cord shall also be used to connect devices directly to one another. At minimum, furnish and install copper patch cords for all Ethernet cabling between devices or between device and patch panel within the same cabinet. Refer to PLANS for required interconnections

2. Each patch cord connector end shall be RJ-45 and shall be the Boot type connector. The connectors at each end shall be preinstalled by the Ethernet patch cord manufacturer
3. The Patch Cord shall be unshielded twisted pair and shall be rated Category 6A
4. The Ethernet copper cable outer jacket shall be Blue.

C. Patch panels:

1. General:
  - a. Approvals: Meet or exceed requirements for Category 6A per TIA/EIA-568-C.2-10
  - b. In addition to the device/wire tagging requirements described in Section 17200 "Instrumentation and Control Cabinets and Associated Equipment", provide additional labels as described below:
    - 1) Overall Connector Panel Labels: Printed on the patch panel case by the Manufacturer. Provide unique, alphanumeric designation
    - 2) Connector Panel Adapter Port Label: Each adapter port on each Connector Panel shall have clearly labeled, printed, alphanumeric designation that is unique to that Connector Panel port and printed by the patch panel manufacturer
    - 3) Terminate copper cabling to patch panel in accordance to TIA/EIA-568-C.2-10 standards
    - 4) Label each port of each patch panel. Furnish and install TTP Continuous polyester thermal transfer label as manufactured by Tyco, with ribbon and printer by label manufacturer. Label shall be white with black lettering of minimum height 1/4"
  - c. Each patch panel shall be accompanied with a typed patch panel schedule with the following columns: Adapter ID, Cable Side, User Side, described as follows:
    - 1) adapter ID: The adapter ID shall be of the form XX-YY, where:
      - a) XX is the Connector Panel identifier shown by the panel manufacturer
      - b) YY shall represent the adapter number within the Connector Panel
    - 2) Cable Side: Indicate the source of the cable. Use the "patch panel tag"-XX-YY designation where applicable
    - 3) User Side: Indicates the device (PLC, patch panel, etc.) connected to the adapter
    - 4) A Hard Copy print out of each Patch Panel Schedule shall be provided to the OWNER and ENGINEER. A soft copy on CD-R media of the patch panel schedule shall also be provided to the OWNER and ENGINEER
    - 5) Employ consistent and uniform application of identifier and adapter numbering assignment to Ethernet Copper cables along the entire span and route of each copper cable.
2. Each Type 1 patch panel shall be as follows:
  - a. Construction: Metal, primed and painted with manufacturer's standard black finish.
  - b. Quantity of Ports: minimum 24.
  - c. Miscellaneous: Color coded front port labeling.
  - d. Mounting: 19" rack mountable. Mount on 19" rack, with all necessary brackets and hardware. Refer to the PLANS.

- e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal.
- f. Mounting Bracket: Where patch panel is to be mounted to a wall or back panel, furnish and install 1U Hinged Wall-Mount 19" rack Patch Panel Mounting Bracket for wall mounting the patch panel:
  - 1) Bracket shall be rated for minimum 8 kg (17 lbs.) weight capacity
  - 2) Bracket shall offset patch panel from wall by a minimum distance of 5.5".
  - 3) Bracket shall allow for wall or back panel mounting a patch panel while providing hinged access to the back of the patch panel to facilitate installation of Ethernet connectors and Ethernet cable termination.
  - 4) Bracket shall have mounting holes spaced 16" apart
  - 5) Bracket shall be painted steel hardware, minimum 14 gauge thickness, mounted with 316 stainless steel screws.
3. Each Type 2 patch panel shall be as follows:
  - a. Construction: Plastic, fully enclosed type,
  - b. Quantity of ports: Minimum 2
  - c. Mounting: Surface mounted. Secure patch panel to backpanel with screws.
  - d. Manufacturer: "Panduit", Model Mini-Com #CBXQ2IW-A, with "Mini-Com TX6A" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal.
4. Each Type 3 patch panel shall be as follows:
  - a. Construction: Plastic, fully enclosed type,
  - b. Quantity of ports: Minimum 12
  - c. Mounting: Surface mounted. Secure patch panel to backpanel with screws.
  - d. Manufacturer: "Panduit", Model Mini-Com # CBXF12IW-AY, with "Mini-Com TX6A" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal.
5. Each Type 4 patch panel shall be as follows:
  - a. Construction: Plastic, fully enclosed type,
  - b. Quantity of ports: Minimum 4
  - c. Mounting: Surface mounted. Secure patch panel to backpanel with screws.
  - d. Manufacturer: "Panduit", Model Mini-Com #CBXQ4AW-A, with "Mini-Com TX6A" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal.
- D. Copper Ethernet Data Communication Cabling:
  1. Copper Ethernet Communication Cabling shall be used to interconnect copper patch panels with each other, or to interconnect Ethernet data outlets to copper patch panels.
  2. The copper Ethernet cabling shall be unshielded, twisted pair, rated Category 6A cabling.
  3. Agency Compliance: TIA/EIA-568-C.2, TIA/EIA-568-C.2-10 Category 6A, IEEE 802.3an 10GBASE-T Ethernet, UL Listed
  4. Number of Pairs: Four
  5. Wire: #23 AWG Bare Copper
  6. Type of Conductors: Solid copper conductors, twisted
  7. Individual Conductor Insulation: Minimum 300 volt polyolefin

8. Individual Conductor Insulation Color: White/Blue Stripe, Blue, White/Orange Stripe, Orange, White/Green Stripe, Green, White/Brown Stripe, Brown
9. Overall Jacket: PVC, include ripcord
10. Overall Jacket Color: Blue
11. Manufacturer: Belden 10GX32, or approved equal.

## **PART 3 EXECUTION**

### **3.01 GENERAL INSTALLATION**

- A. The ICS shall furnish labor, materials, equipment, and incidentals required to install the system in accordance with specification section 17100 and 17600.
- B. The ICS shall be responsible for ensuring that field wiring for power and signal circuits is correct and wired in accordance with best industry practice. Also, the ICS shall be responsible for providing all necessary system grounding to insure a satisfactory functioning installation.

### **3.02 ETHERNET SYSTEM COPPER CABLING- SOURCE QUALITY CONTROL**

- A. Copper Ethernet Cable System Testing:
  1. After installation of Copper Ethernet Cable System, ICS shall perform testing of the cable system to assure compliance of the installed system with the TIA/EIA-568-C.2-10 Category 6A requirements. Testing shall be performed for all installed copper cable systems, including used and unused links, from end-to-end, including all data outlets, connectors, patch panels, patch cords, etc
  2. Copper Ethernet Cable System Test reports shall be submitted to the engineer and owner for review and approval. The test report shall document, for each copper data link, description of the link and components therein, the testing method used, test results, and demonstrate compliance with TIA/EIA-568-C.2-10 of the link. If any installed link does not meet the TIA/EIA-568-C.2-10 Category 6A requirements, ICS shall repair/modify link to assure it is compliant with TIA/EIA-568-C.2-10 Category 6A standard at no additional cost to the owner.

### **3.03 TESTS (GENERAL)**

- A. Refer to Section 17100.

### **3.04 INITIAL ON-SITE SYSTEM DEMONSTRATION TESTS**

- A. Programmable Logic Controllers PLCs:
  1. Test all loop-specific functions and demonstrate all I/O Points.
  2. Test all non-loop-specific functions including, but not limited to, the following:
    - a. Failure Mode and Backup Procedures: Power failure, auto restart, retentive outputs.
  3. Refer to Section 17100 for additional test requirements.

**3.05 OPERATIONAL READINESS TEST (ORT) AND PERFORMANCE ACCEPTANCE TESTS (PAT)**

- A. Refer to Section 17100.

**3.06 MEASUREMENT AND PAYMENT**

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION